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THE ROOT-ENDINGS OF BEECH, MAPLE AND DOGWOOD AS FOUND IN THE EASTERN USA

O KORZENIACH OSTATNIEGO RZĘDU
W SYSTEMACH KORZENIOWYCH BUKA,
KLONU I DERENIA, JAKIE FORMUJĄ SIĘ W GLEBACH
WSCHODNICH STANÓW AMERYKI PÓŁNOCNEJ

О КОРНЯХ ПОСЛЕДНЕГО РАЗРЯДА В КОРНЕВЫХ СИСТЕМАХ БУКА,
КЛЕНА И КИЗИЛА, КАКИЕ ОБРАЗУЮТСЯ В ПОЧВАХ ВОСТОЧНЫХ ШТАТОВ США

ÜBER DIE KURZWURZELN UND ENDWURZELN DER BUCHE,
DES AHORNS UND DES HARTRIEGELS, DIE SICH IN BÖDEN
DER ÖSTLICHEN STAATEN NORDAMERIKAS BILDEN

INTRODUCTION

The USA as a locus for plant study. The large size of the USA is an advantage to the student of Plant Science, in that he is able to study material from widely different climates and soils without leaving the country; and he can conveniently reach almost any area by excellent roads. At the same time, rapid increase in population with consequent destruction of natural vegetation make the areas available for study constantly fewer. The old days of thirty-five years ago, when the Plant Scientist went at will through country that had changed but little from Colonial days, stopping where he chose, finding camp-sites innumerable, and meeting with a friendly public that was still markedly separated into rural versus urban, — those days are completely gone. Today the eastern USA consists of urban and suburban areas, with „housing developments“ constantly spreading and destroying farm — and wood-land; it consists also of mechanized and specialized farms, and of Statemanaged forests; and there is almost no open country in the sense of a generation ago: nor is there any longer a friendly public. The so-called open country is mishandled and very often defiled with all sorts of refuse, and even National Forests are used by the public for deposit of waste. In all my work, from Canada to the Gulf of Mexico, I did not find a single forest

or woodland that was not littered with refuse; and in such camp-sites as I could find it was necessary to clear away tin cans and other litter before camp could be made. This was always true, even in the most remote areas. Vermont, which still curbs liquor, was the cleanest State; yet even here was litter left by visitors from other States.

Securing of data. The amount of data, therefore, which could be acquired for such a study as this was accumulated only with difficulty. Not only did it consume much time in hunting for natural areas, but the distances involved required time for driving: thus, it takes me a week of driving to go to Florida and back. Arrived in the area desired, one hunts a retired place for work; but suspicious peasants behold the scientist and send for the police who then cross-examine him; and only finally is he able to dig for roots — which are often hard to secure as the delicate rootlets break off at a touch.

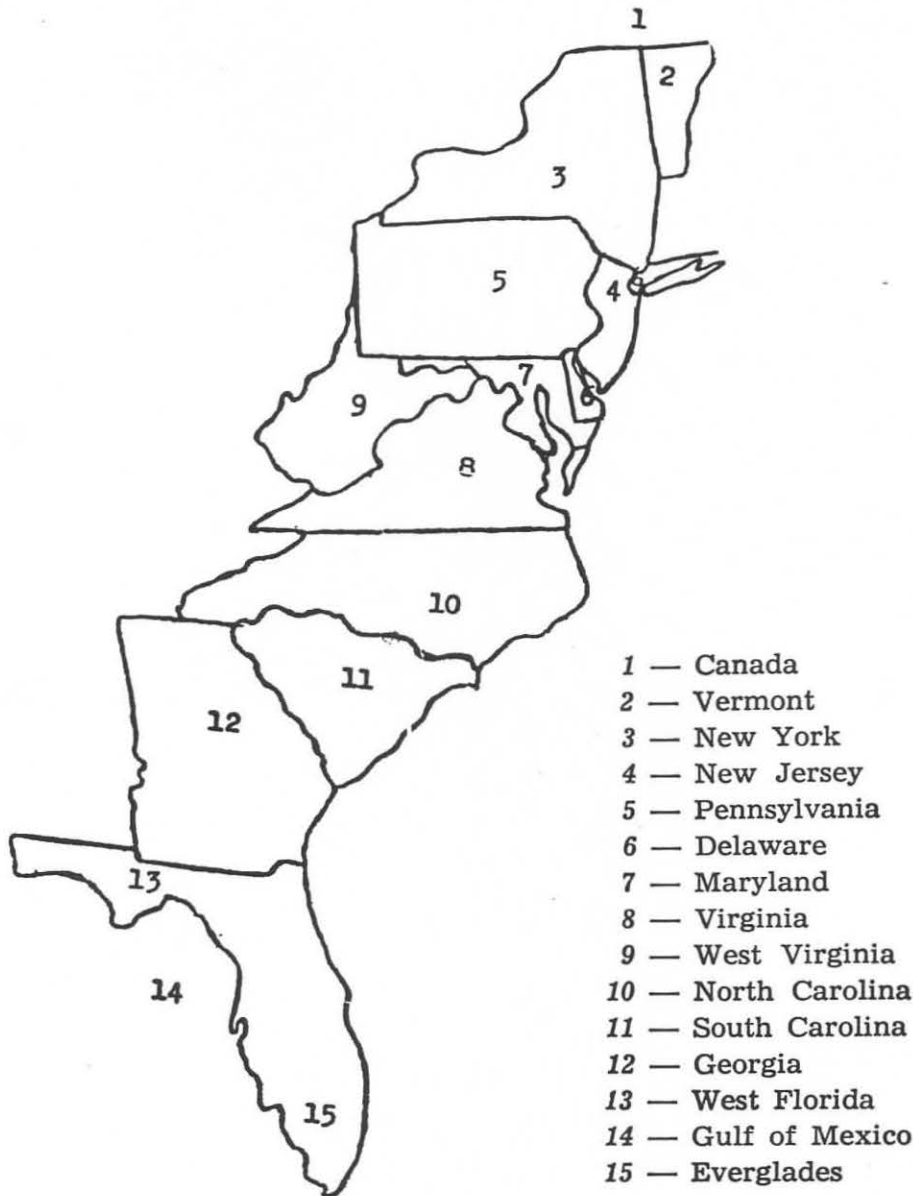
The area. The area studied extended from 27° to 44° N latitude, or an area about 2000 miles long (by road), and in breadth about 300 miles. Collections of samples were made fortuitously in favorable localities and studied for the most part at once, in the field. The area comprised portions of the Appalachian Mountains and outliers, the foothills or piedmont, and the Atlantic coastal plain. The Appalachian Mountains consist of parallel ridges that extend north-eastward from Georgia to New York State, where they are succeeded by detached mountain masses that extend into New England, in Vermont being known as the Green Mountains. At their southern extremity the Appalachians end in hills that cross the West Florida border and form the Appalachianic Hills.

The piedmont area consists of mostly low ridges that parallel the mountains, with vallies between, and uplands. In reality, the piedmont consists of a series of plateaus that rise step-like from the coastal plain; and they are eroded into a diversified topography by a mostly dendritic drainage.

The coastal plain is an undulant sand and gravel area that commences on Long Island and extends southward along the coast between the Atlantic Ocean and the piedmont, in an area that increases in width until in Georgia it is close to 300 miles wide. There is little of the seacoast that is left „undeveloped“, and the salt-marsh areas are diminishing as they are drained and built upon; but quite a little of the swampy coastal forest is left. In general, collecting is most difficult in the coastal area, of the three regions investigated.

The three regions are further diversified by glaciation in their northern parts. New England and New York State (to the middle of Long Island), the northern portion of New Jersey, and some of northern Pennsylvania are glaciated; and have soils very different to the residual and alluvial soils of the other States. Again, in the South, especially from mid-North

Carolina to Florida, the piedmont soils are an heavy red clay that is poor and sterile, and has been badly eroded. Florida, and all the coastal area, have sandy soils that in portions are calcareous or marly; while in the southern Peninsula of Florida there are black muck soils beneath a sub-tropical sun. Hence, the range in soils of the areas sampled is great.



Sketch Map of the ATLANTIC SEABOARD USA

Climate of the eastern USA. So, too, is there a range of climate. In general, eastern USA has two climatic zones, the cold temperate and the warm temperate, with alpine conditions in the White Mountains of New England and with sub-tropical climate at the very tip of Peninsular Florida. But a fact that is often overlooked is, that there is just one sort of climate from Hudson Bay to the Gulf of Mexico, with variations at any one place compounded of latitude and local conditions. The Appalachian Mountains are too low to check the movement of air masses

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seriously, hence warm air masses sweep northward from the Gulf, or cold masses sweep southward from the Arctic. These movements occur all the year and result in a climate that consists of warm waves alternating with cold waves. No part of the eastern seaboard has a really warm climate: I have camped on the shore of the Gulf of Mexico when the temperature stood at 20° F and hail pelted the Gulf waters: I have seen snowbirds twittering in a South Carolina frozen corn-field, just as they do in Pennsylvania or New York; while in summer the Northern States swelter in sub-tropical heat.

A certain popular writer played on superstition by writing a book on „following the spring“ from southern Florida to the Maritime Provinces. The idea is untrue because there is no such succession: spring comes at the same time to all of the eastern seaboard, for, when a mild wave occurs on the south Atlantic shores of the USA, water is dripping from the trapper's shack in the Hudson Bay region. An April cold wave that sends the trapper to his fireside makes the Southerner shiver and stay indoors. The advance of spring is a question of degrees, of relative development, and not of a step-like advance from south to north. In northern Florida, the season of frost and cold and ice in one's water bucket is short; and by the last week of January the cold season is over, and fruit-trees burst into bloom. At the same time, the Wild Arum spathes have opened in Pennsylvania swamps, a thousand miles to the northward; while snow becomes mushy in Ontario, still another thousand miles north. In any study of plant rootlets, we must remember the effects of climate upon them, and realize that it is a question of degrees and not usually of absolute differences in kind.

Effect of climate on root endings. Climate often affects plants indirectly through the soils. A prominent difference between the forest vegetation of Vermont and of Pennsylvania (at lower elevations) is the presence of evergreen trees, particularly spruce, in the former and their absence in the latter. Now spruce, when cultivated, grows well in Pennsylvania, if the seedlings are carefully protected through the winter. In Vermont, the soil freezes and stays frozen for the duration of the cold season, but in Pennsylvania the soil freezes and thaws times without number with the consequence that unprotected seedlings are heaved out of the ground. After a few years the spruce develops roots that penetrate deep enough to hold the tree in place in spite of frost action. Native Pennsylvania plants, like *Juglans*, *Carya* and *Quercus*, develop a tap-root the first season that holds the seedling in place.

Again, plants from the South might stand the northern air temperatures of winter if the roots were not frozen. As an illustration: I brought a seedling *Pinus echinata* Mill. from Jones County, Georgia, to my property in Pennsylvania; and it grew well in summer but died back in winter

because the ground froze about the roots and stopped intake of water; while *Pinus Strobus* L. seedlings grew close by without damage. Of course it is true that *P. echinata* grows natively in Pennsylvania, and a native seedling might have behaved differently.

The plants studied. Three sorts of tree-root-endings were chosen for study, partly because they had a particular kind of root structure, and partly because of their wide distribution. These trees were beech (*Fagus grandifolia* Ehrh.), red maple (*Acer carolinianum* Small and *A. rubrum* L.), and dogwood (*Cornus florida* L.). All of these trees grow in the Atlantic seaboard States, from New England to Florida, in a wide range of soils and climate; and data secured from their study should give some evidence as to the nutritive apparatus employed by each sort of tree, and the effect of soil and climate upon them.

The beech (*Fagus*) which was studied is considered to be all of the same species; but it may be a mixture of species, or at least of ecospecies. Since no one has ever successfully defined the „species“, and since botanical effort for a century has been devoted to obscuring its nature and being, one is necessarily wary of speaking about „species“: it is safer to talk about sorts or kinds of plants. Perhaps the best attempt at defining the species raised only a storm of critical rejection: „The species is a fluid unit, held to its present form by forces it cannot overcome“ (Austin Clarke). Hence we discuss *Fagus* as it occurs from Canada to West Florida without asserting that it is necessarily all of the same „species“. *Fagus* neatly illustrates the coralloid sort of root-ending.

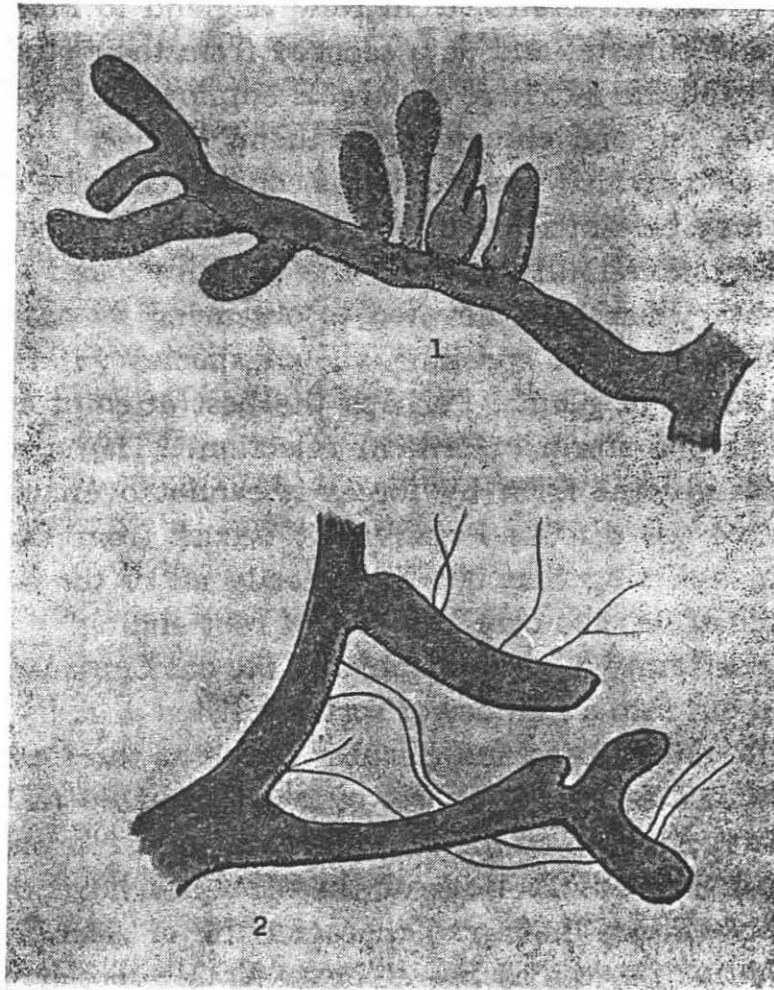
Red maple is certainly a group name; and the old Linnaean *Acer rubrum* has been sorted out into a number of sorts, as listed e. g., by Rehder in his „Manual of Cultivated Trees and Shrubs“, some of the sorts being raised to specific status. This study reports on swamp maple (*A. carolinianum* Small), and the red maple of the Middle States that for want of a better name we call *A. rubrum* L. Both of these maples have the moniliform or „beaded“ root-ending that is so characteristic of *Acer*.

Dogwood (*Cornus florida* L.) has elongate simple rootlets which branch in monopodial fashion. Dogwood is widely distributed along the eastern seaboard, while another species is found on the Pacific coast. In dogwood we also consider all the trees studied as belonging to one „species“.

A STUDY OF ROOT-ENDINGS IN BEECH

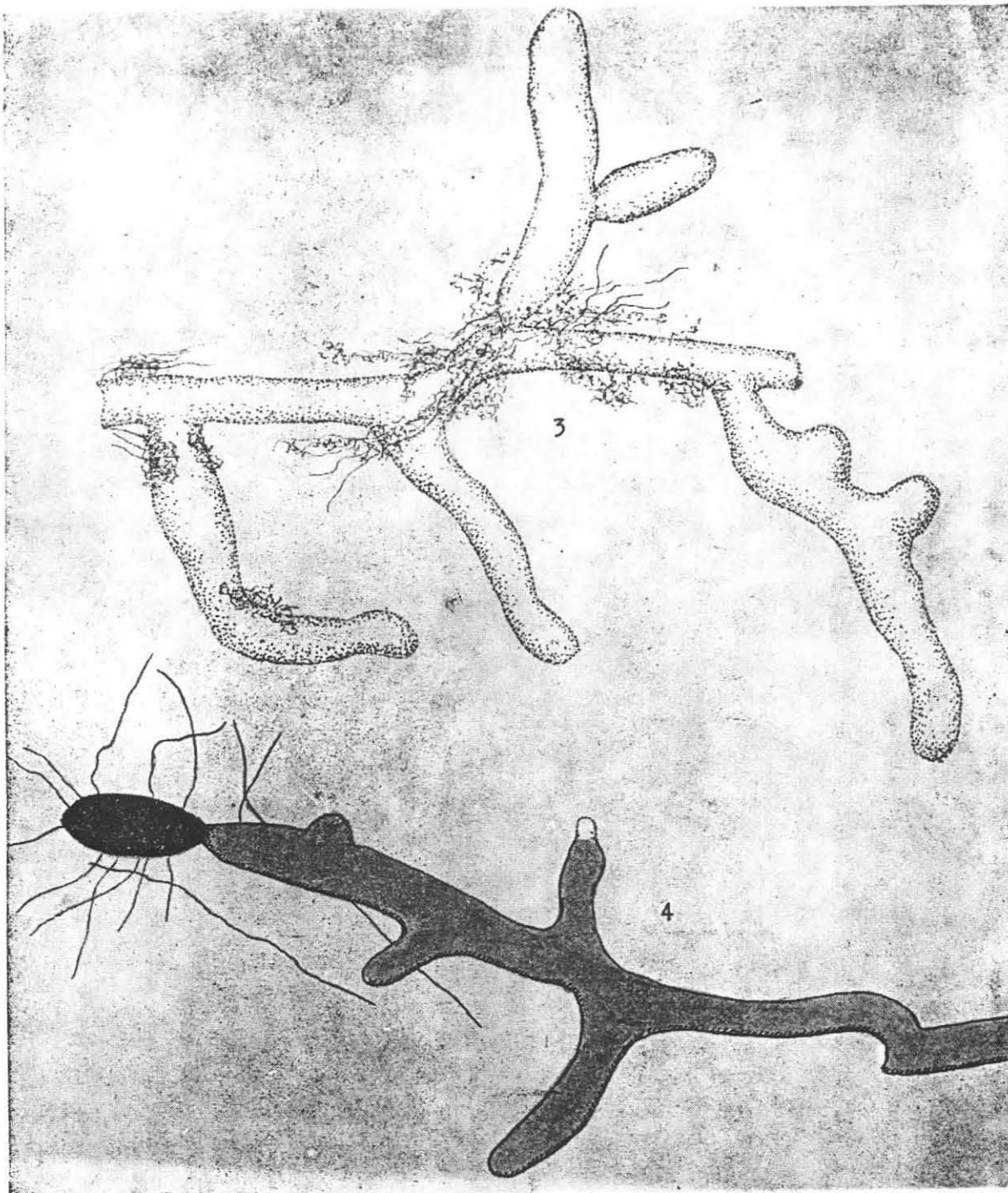
Beech in Vermont. Beech was briefly studied at Gaysville, Windsor County, the middle of May, 1956. At that time, spring was just coming to the Green Mountains; farmers were starting to plow some sheltered bottom lands, while red maple (a northern sort, not the same as what we call *A. rubrum*) had red and gold flowers on leafless twigs, and

in the woods were some early spring flowers; but in a glen, under spruce trees, I saw a large mass of unmelted ice. Here in the mixed deciduous-evergreen forest that clothed steep and rocky mountain slopes were scattered trees of beech. The rootlets, when uncovered, were found to be mostly black, as overwintered mycorrhizae are apt to be; and there was no renewed spring growth visible. My examination was cursory; but it did show that beech in Vermont has the usual coralloid mycorrhizae of *Fagus* (figs. 1, 2).



Beech in Vermont

Beech in New York State. The middle of October, 1957, I was camped in Sullivan County, a short distance north of the Delaware River. It was frosty weather, and the landscape, dominated by *Pinus Strobus* L., had a wintry look. While the woodland was largely evergreen, there were numerous deciduous trees, especially in glens along streams. Examining rootlets of beech which were formed abundantly in black humus of the habitat, it was found that there were copious new mycorrhizae with mycelium, as shown in fig. 3. Later, rootlets were examined that were collected on an upland slope above the River near Narrowsburg, and here



Beech in New York State

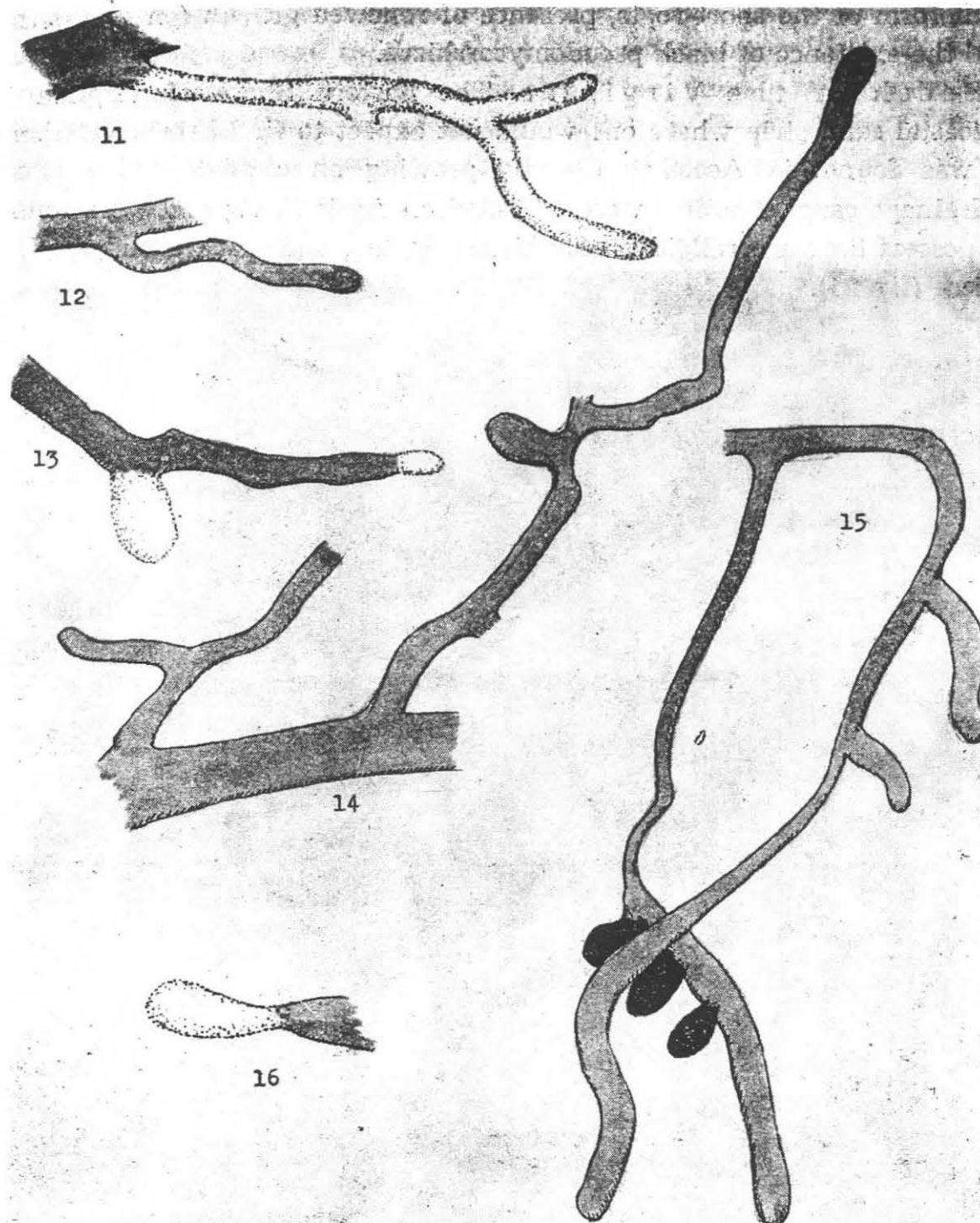
were found old black mycorrhizae (fig 4) yet with new growth starting from them: also the nigrostrigosus sort of short-root was found.

Beech in Pennsylvania. Beech is abundant in southeastern Pennsylvania and dominates the „climax forest“ of this area. In old woods on Chester loam, beech often forms pure stands, and in such woods the material was collected which is here illustrated. The characteristic form of the rootlets is shown in figs 5, 6, magnified about ten times; while young spring growth is shown, more highly magnified, in figs. 7—9 Fig. 7 shows something like a dichotomy, found on March 31, 1956, while fig. 8 shows



Beech in Pennsylvania

an average renewal of growth as found on April 2, New growth is also found during the summer, as indicated by fig. 9, which was drawn from a collection of June 13; and on the same date were found the pseudomycorrhizae shown in fig. 10.

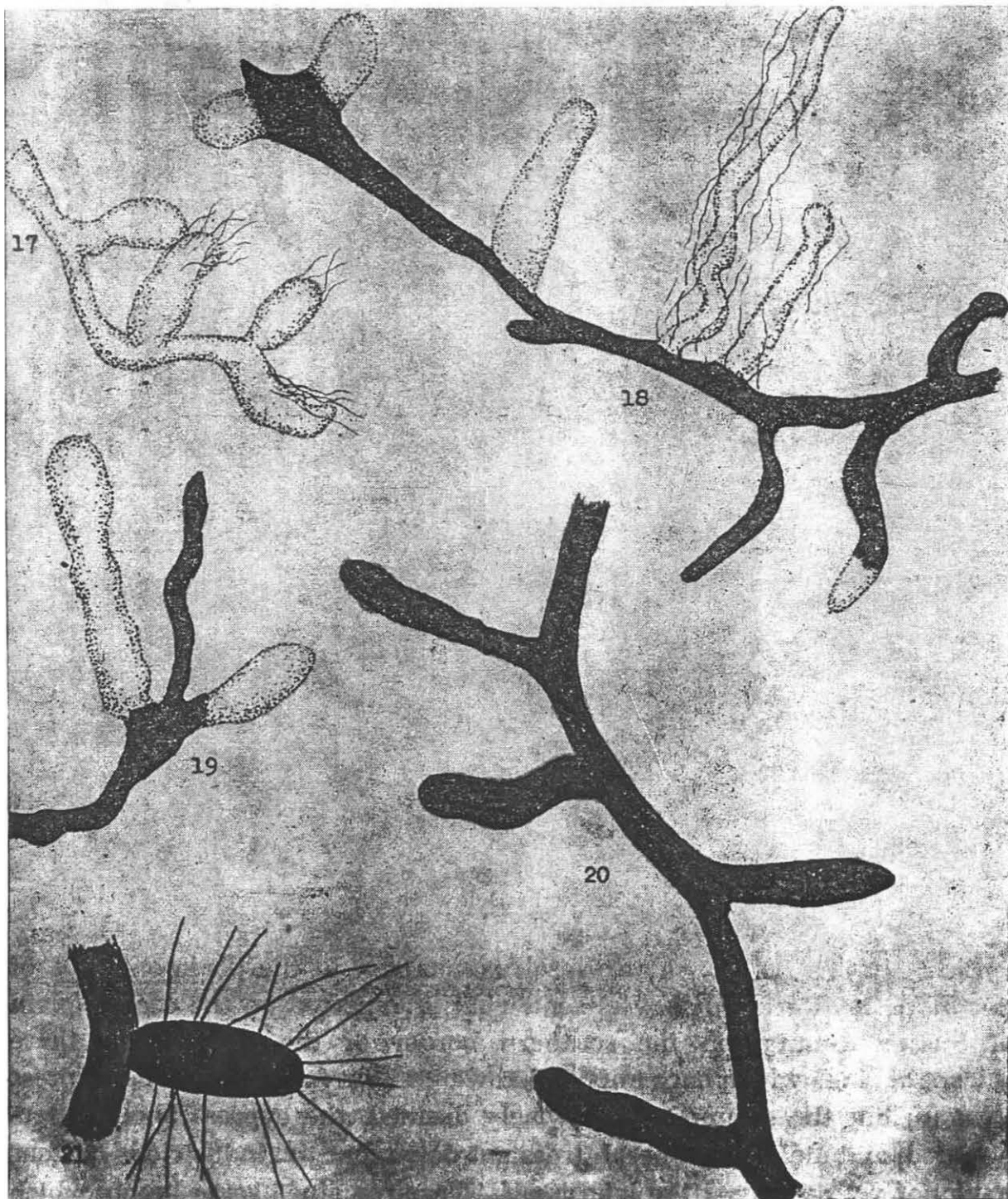


Beech in Delaware

Beech in Delaware. Beech is common in the piedmont hills of northern Delaware; but it was somewhat unexpected on the coastal plain of Sussex County, on the southern border of the State. Here there is a slight ridge which once impounded waters that formed The Big Cypress Swamp; but the swamp was unwisely drained, the cypress about exterminated, and most of the beech trees cut down, but the industrious citizens have not yet destroyed the land itself. There remained some beech, which provided the material shown in figs. 11—16 These exhibit typical corra-

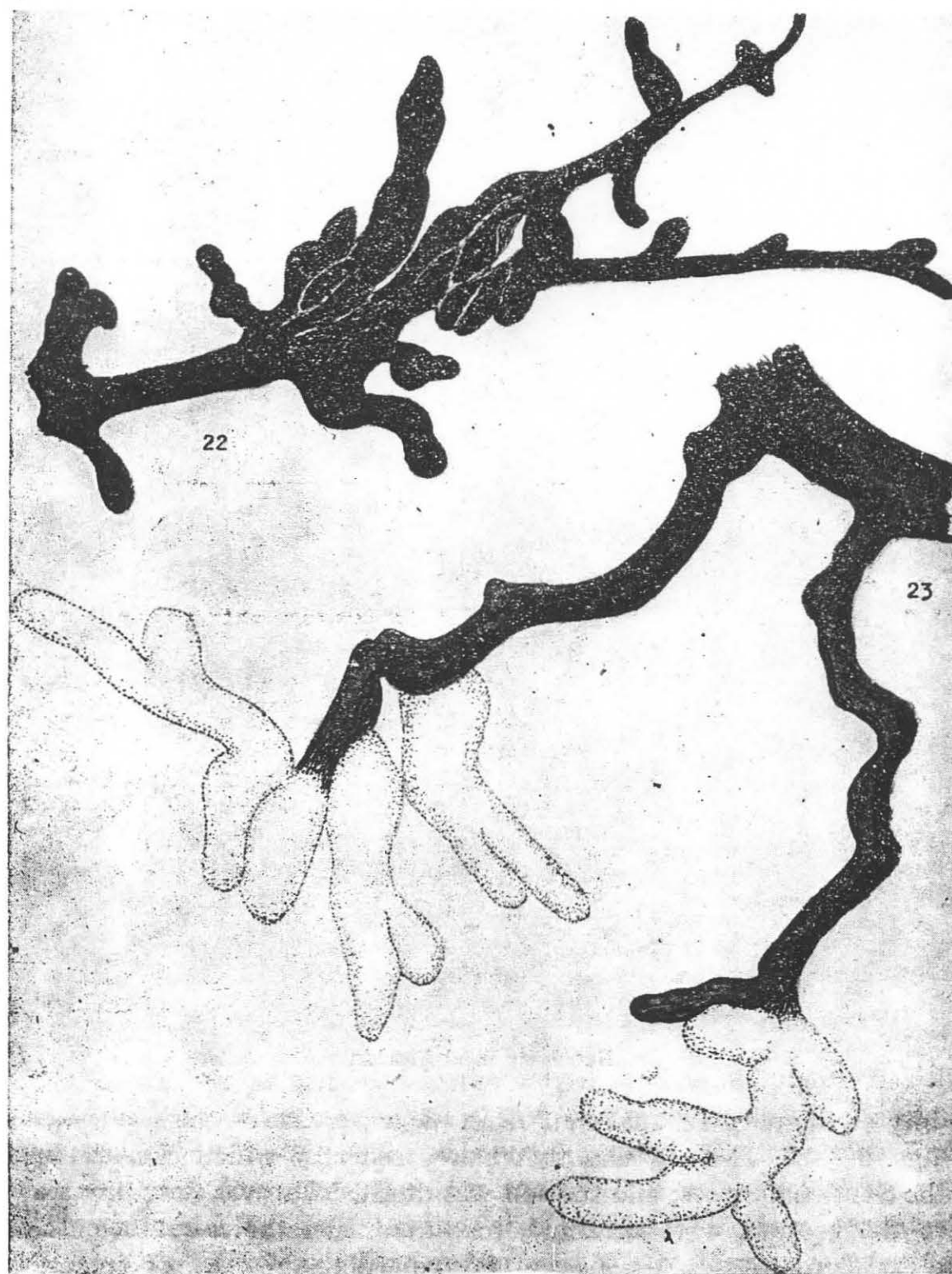
loid form of the short-roots, presence of renewed growth (on May 9 th), and the existence of black pseudomycorrhizae.

Beech in the Virginias. The Eastern Shore of Virginia is a coastal sand strip where one would not expect to find beech; yet there it was found, in Accomac County, growing on a slight ridge along a drainage canal. Rootlets were collected on April 11 th; and were found to possess brown coralloid mycorrhizae (fig. 20), and black pseudomycorrhizae (fig. 21).



Beech in The Virginias

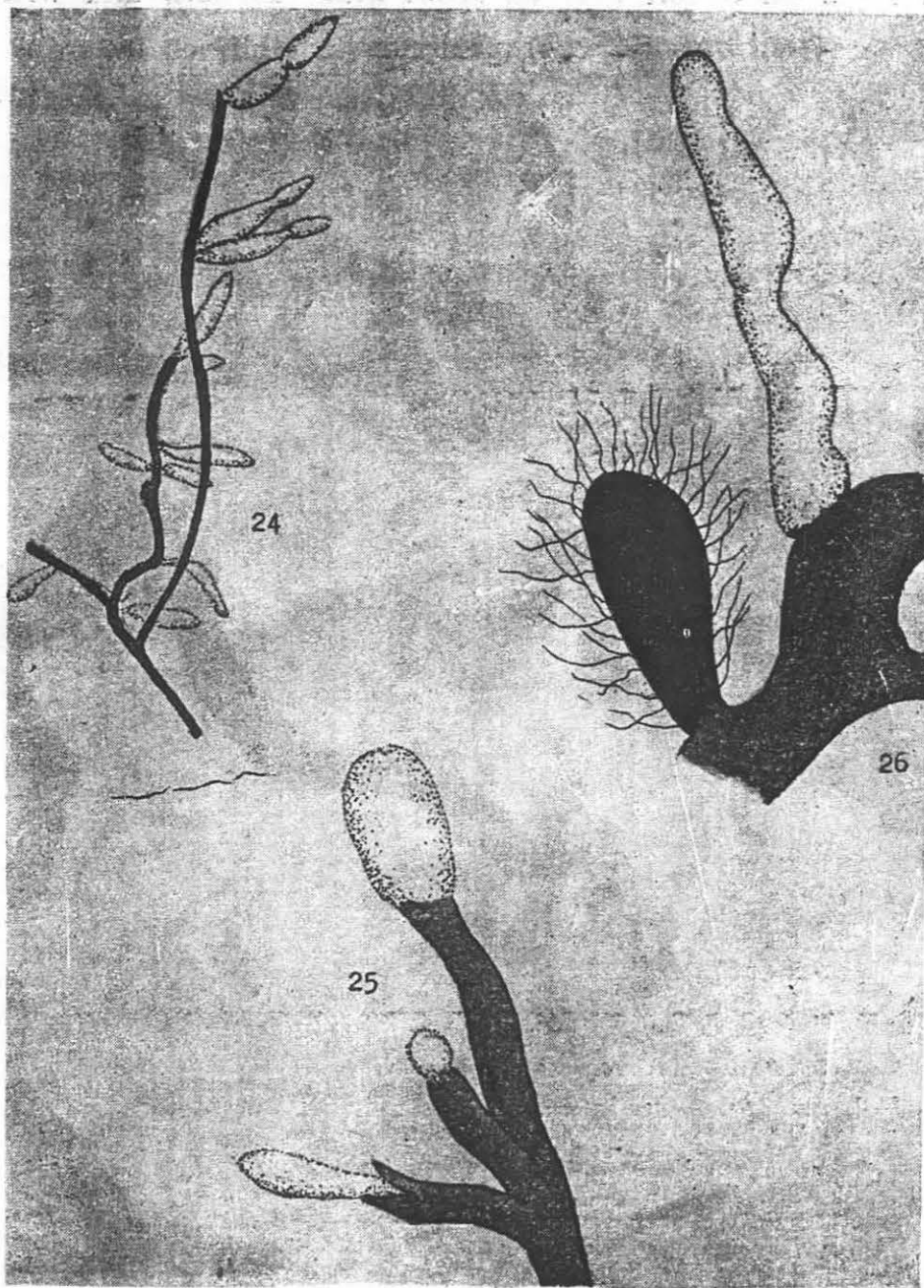
The mountains of West Virginia form a very different habitat, and one more suitable to beech. In Hampshire County (adjoining Virginia), beech was found mixed in with a mostly hardwood forest; but presence of *Pinus Strobus* L., *Tsuga canadensis* (L.) Carr, and *Betula lutea* Michx. f. showed that the forest was of the Canadian, rather than the Austroriparian life zone. Here on a soil derived from metaquartzite and with ample



Beech in Georgia

moisture, beech roots were found with an abundance of renewed growth (figs. 17—19). New little coralloid short-roots were pure white, only later turning brown.

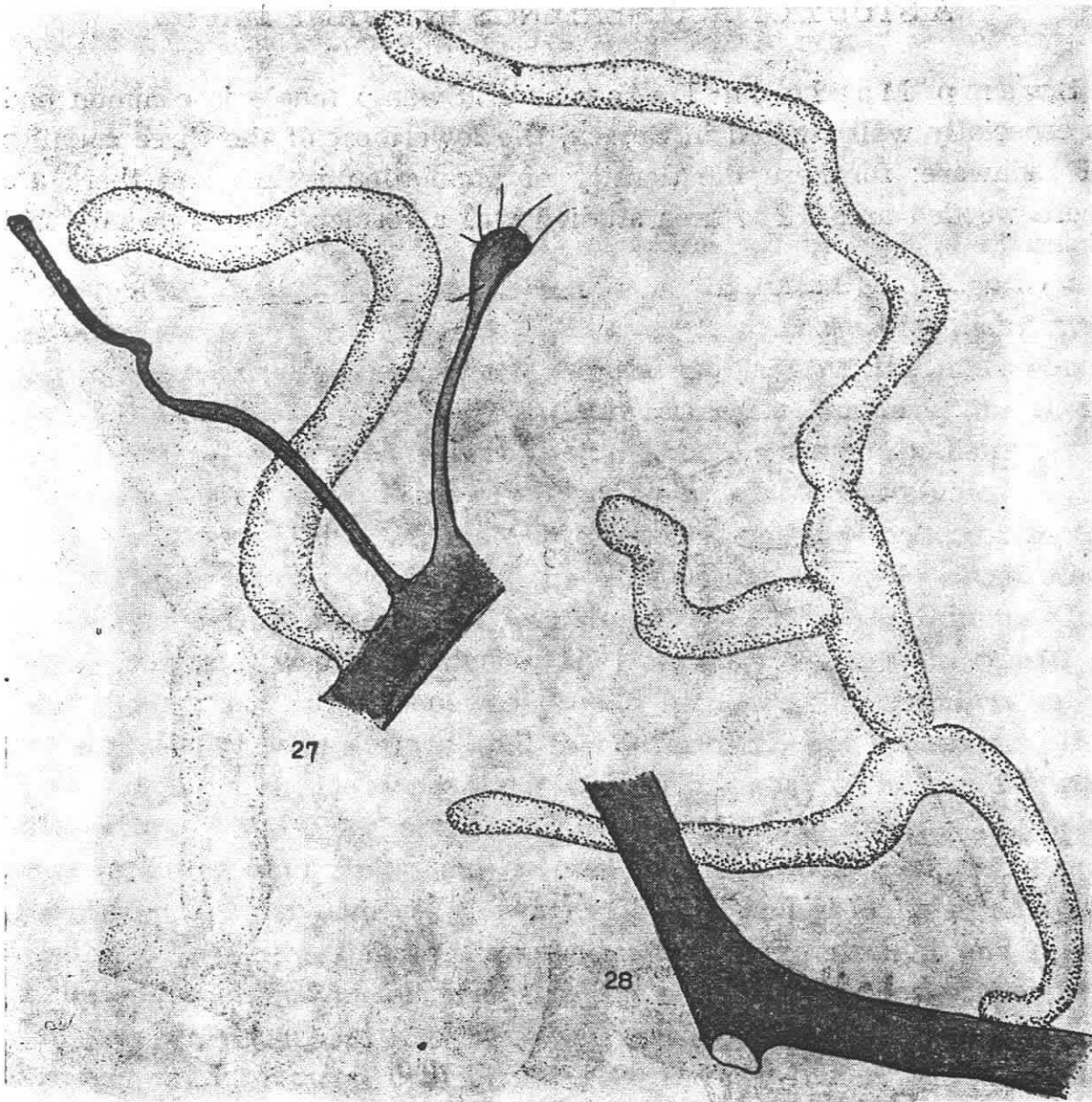
Beech in Georgia. Beech is not common in the foothill country of western Georgia; but some trees of this „species“ were found in Quitman



Beech in West Florida

County on January 22, 1957; and from them were made the studies shown in figs. 22—23. The soil was that heavy red clay which is so prevalent in the Southern States; and the soil was moist, for it was the rainy season. Here the rootlets were coralloid, modified from the usual fagoid form into nodulous masses, the heavy clay retarding growth and compacting the tissues. As the result of the rains, much new growth was observed.

Beech in West Florida. Beech is found in the Appalachicola Hills of Gadsden. County. These hills are of slight elevation, but they have the drainage yet constant moisture content, with underlying calcareous rock that makes a site agreeable to beech. It does not have the aspect of northern beech: certainly it does not have the massive trunks, the dark blue-greys of stem and twig, the rich luxuriance of foliage found in



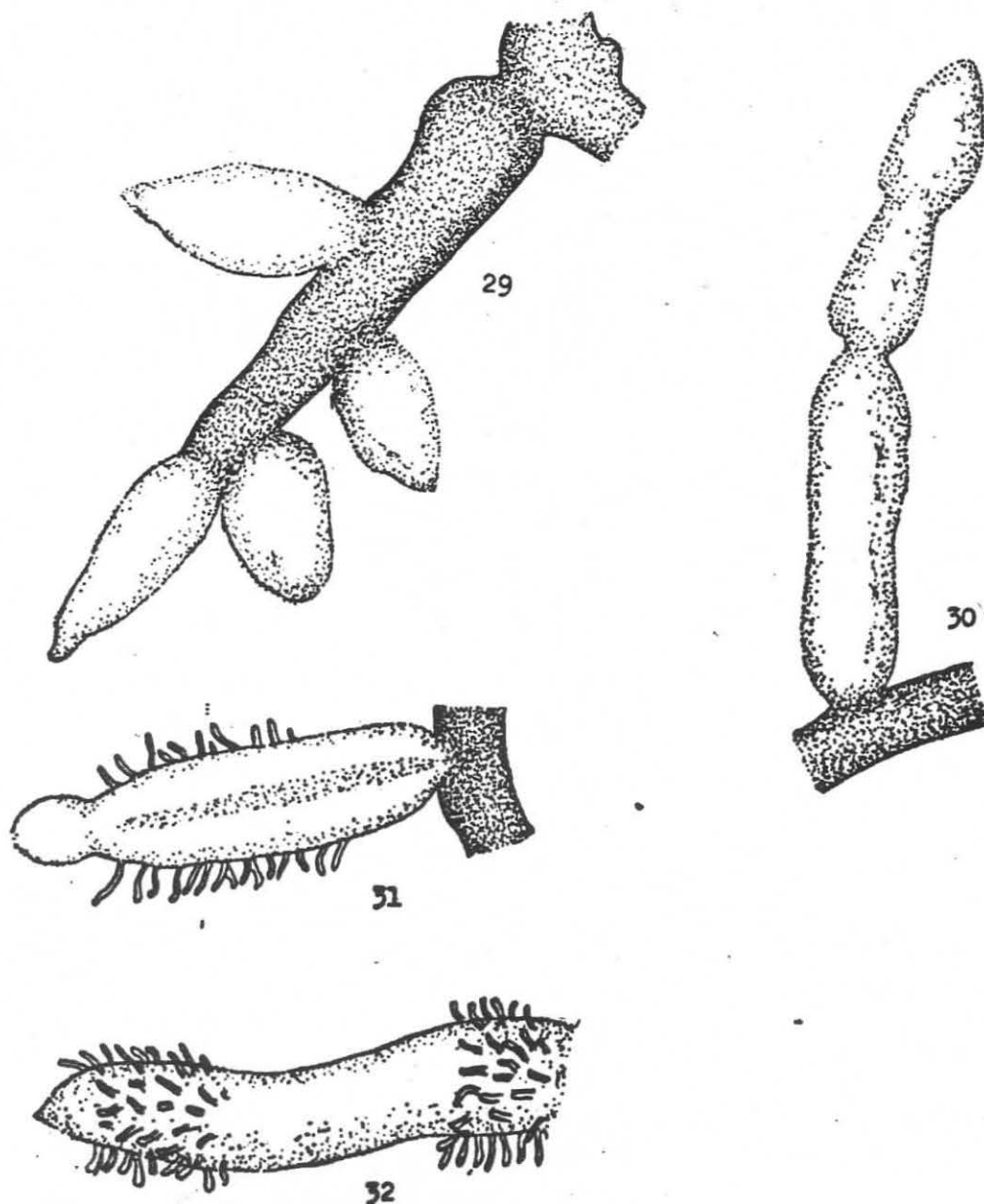
Beech in West Florida

northern beech; but (as was seen in the winter months of 1956) it has the coralloid form of rootlets, the white new tips of growth, and the pseudomycorrhizae (figs. 24—26) as in northern material. Yet one also finds curious structures (figs. 27—28) that perhaps result from special soil and climatic conditions. It may be recalled that beech in Florida never knows a frozen soil or rootlet, whereas in Vermont the roots are frozen seven months of the year. Again, in Florida the soil water is always warm

whereas in the north it is cold. While camped in these Florida hills I dipped water from brooklets as they issued from a sand-bank: the water was warm but became cool for drinking only after it had stood for a time. Warm water and soil may account for some of the odd root structures found in beech and other plants growing here.

A STUDY OF ROOT-ENDINGS IN SWAMP MAPLE

Swamp Maple in Delaware. Swamp maple is common and is especially well studied in Sussex, the lowermost of the three counties of Delaware; for here the density of population is less and there are more wooded areas. The area studied was a former cypress swamp that



Swamp Maple in Delaware

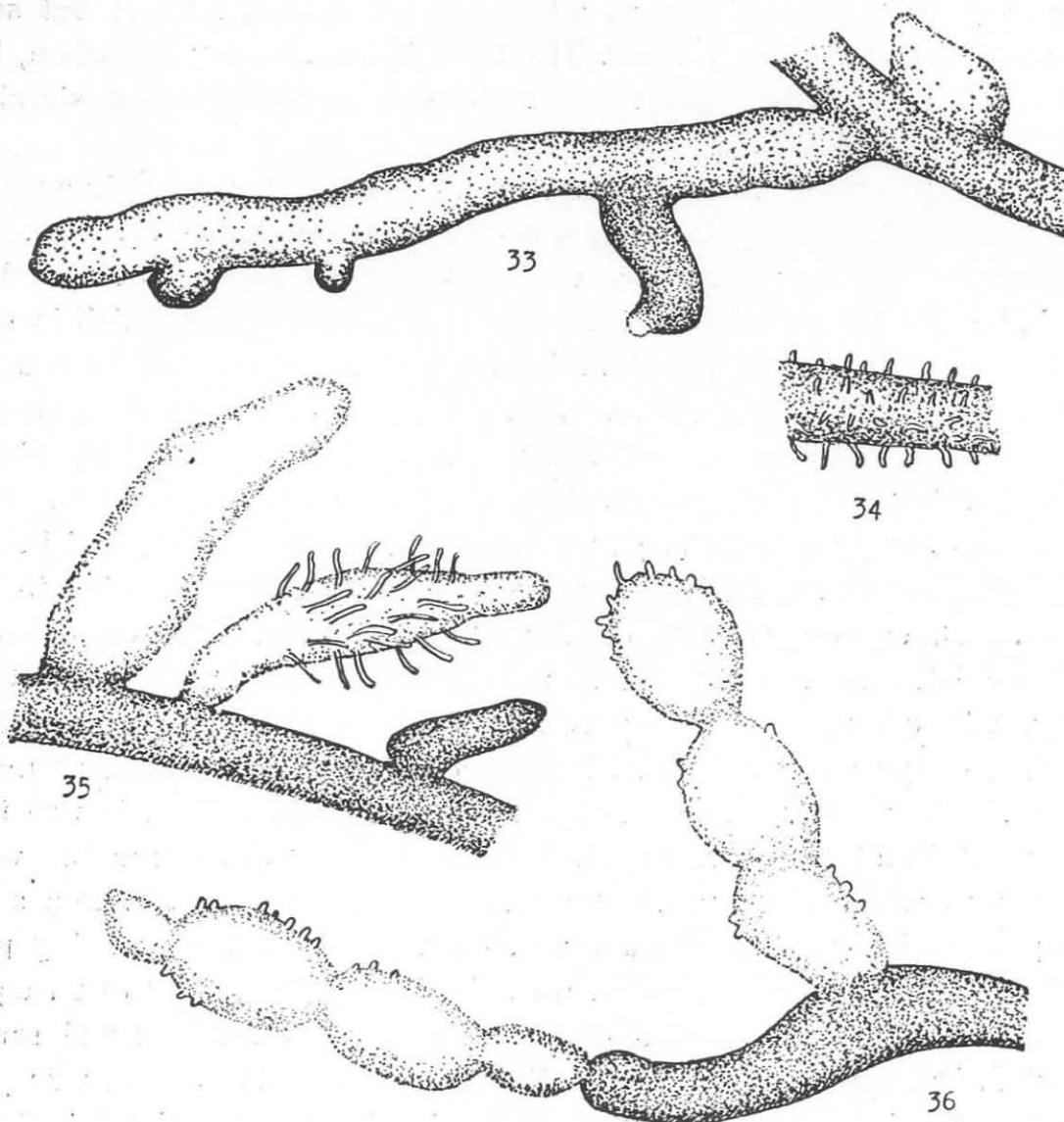
was unfortunately drained under the hallucination that rich farmland would result, but actually there resulted a poor raw-humus soil. The cypress swamp, carefully managed, would have yielded a steady supply of valuable lumber: now there is virtually nothing. However, quite a few maples have come up; and rootlets from these were studied (May 10): they formed mats of growth through innumerable branchings, but seen separately they were moniliform, of whiteness when first formed but soon darkening to a dark honey color. The moniliform „beads“ are often, but not always, beset with short setae or hyphal projections that simulate root-hairs (figs. 29—32).

Swamp Maple in New Jersey. A seedling growing in a rotted log at Bennett, Cape May County, was examined on August 31, 1929. The rootlets appeared dry; and were copiously matted because of abundant growth. They were growing in the humus of the rotted log which in turn rested on coastal sand. Under the microscope it was seen that the rootlets had the usual moniliform character of the maples; but the mycorrhizae were elongate. Setae were abundant and formed a „fur“ over the short-roots, covering even the apical region; and there were no root-hairs.

Swamp Maple in Maryland. Swamp maple was studied in two areas. On October 26, 1929, material of this maple was collected in the Battle Creek cypress swamp, on the Western Shore, from black muck of the undisturbed swamp; and was studied at The Johns Hopkins University, where I was in residence. The rootlets were seen to consist of moniliform mycorrhizae, renewed growth being chiefly apical, as many as four „beads“ being formed, and there were frequent branches so that it was much like the Delaware material described above. The monilae were often setose while older portions showed evident mycoderm. The setae were produced abundantly and covered over the apex, each being produced from a basal „cell“ as shown in fig. 53 d and growing to an equal length, so that they simulated root-hairs: they were straight and rarely contorted. Examined histologically, it was seen that the cortex was partially broken down and that large yellowish hyphae (of about half the diameter of the cortical cell) bent within the cell-lumen. These hyphae appeared to grow through the cortical cell-walls at will. Several layers of cells in the endodermal region were filled with a granular yellow substance; and similar material region were filled with a granular yellow parenchyma.

Swamp maple was also observed on the Eastern Shore of Maryland, in the Pocomoke State Forest: here the tree commonly grows in low wet woods on coastal sands. Root material was collected and studied the middle of April, 1957; and it was found to be mycorrhizal, some of the mycorrhizae being brown over-wintered short-roots while others were new spring

growth. The trees were leafless and just coming into bloom: the climate was cold and there was quite a heavy fall of snow while I was in camp. Old and new growths were in close juxtaposition (figs. 33, 35), the new growth being setose and often consisting of elongate rootlets or roots of



Swamp Maple on The Eastern Shore

extension, as in the New Jersey material; but these elongate rootlets are also setose (fig. 34). Some of the short-roots were retarded or distorted, and were perhaps non-functional.

Swamp Maple in Virginia's Eastern Shore. I was lured to Accomac County by reading accounts of Chincoteague Island in a certain popular magazine which gave the impression that here one would find a nearly virgin wild. What I found was a much built-up country, with a city on the island; and there was little natural vegetation left.

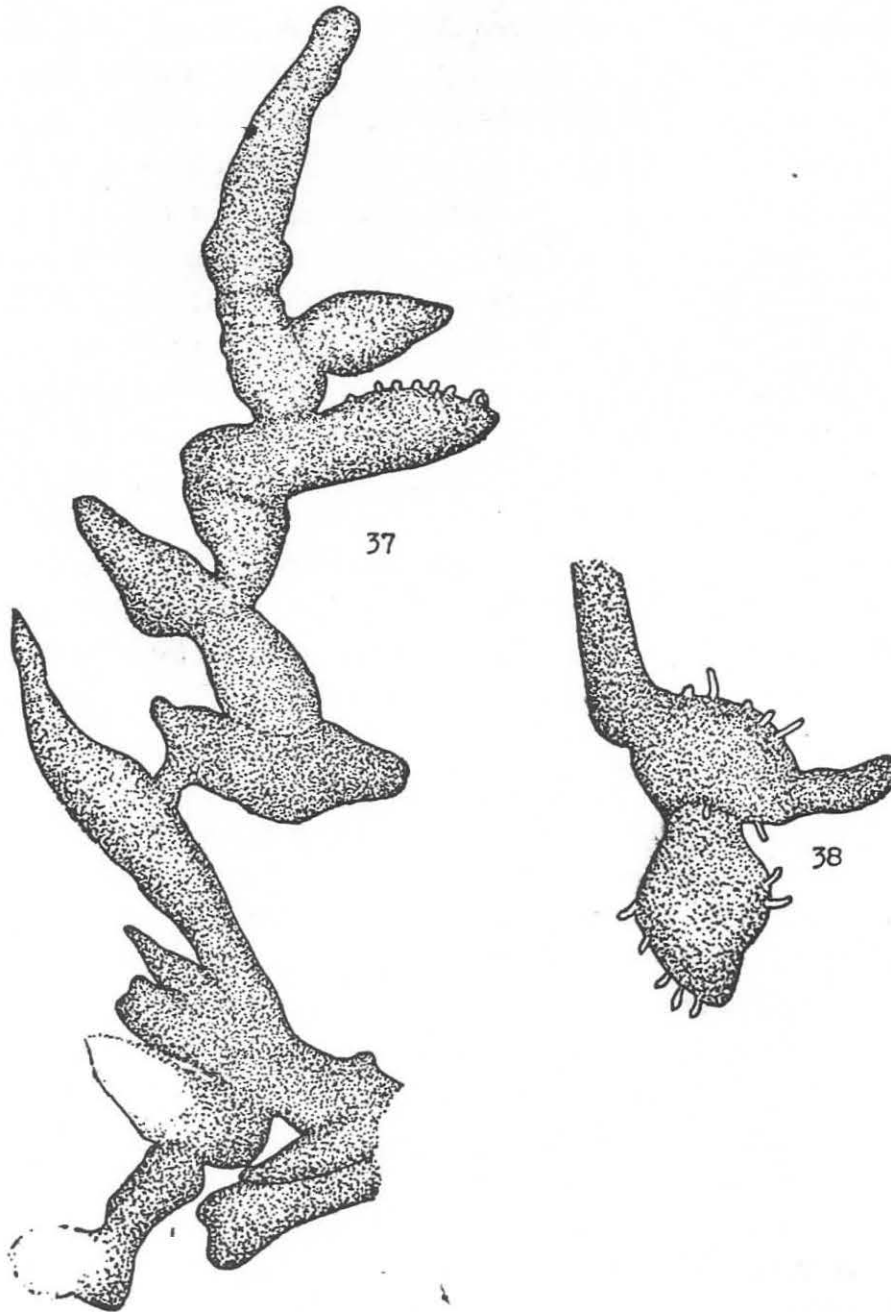
I attempted to enter one wooded lot and was driven off by the irate owner; but later discovered a building lot not yet denuded, and here I collected some material. The soil was sandy and the area was similar to others on the Eastern Shore. Moniliform mycorrhizae had been formed both apically and laterally, but especially apically (like the New Jersey material again). Over-wintered mycorrhizae were dark in color, the new growths white; and there were small setae or papillae on the „beads“ (fig. 36).

Swamp Maple in Georgia. Swamp maple was studied in Quitman County on January 29, 1957. This locality is in west central Georgia, near the Appalachicola River and therefore in upland country; but the swamps are coastal in flora. The soil is a heavy red clay which was derived probably from decay of granitic rock; and root development shows markedly the effect of growth in this medium. One needs but to glance at fig. 37 to see what a strange formation results when the rootlets grow in so unfavorable a medium; for apical growth is retarded and lateral branches are distorted to one side or another as the rootlet forces its way into the resistant clay soil. But even here, and in January, there was renewed growth and small white mycorrhizae were present. (Winter is the rainy season: there was a thunderstorm while I was in camp). The monilae are not as regularly formed as in a sandy or humus site, and there is not as copious development of setae. Curious hypertrophies are found (fig. 38), beset with setose projections; but such abnormalities are common in the South.

Swamp Maple in West Florida. I camped in the hills of Gadsden County through January 1956 and December; and January 1957. Here swamp maple is common, being found on low ground along brooks that are tributary to Flat Creek and other branches of the Appalachicola River; and it ascends somewhat the moist slopes, particularly those that are north-facing. About a dozen of the trees were sampled and their rootlets studied: all the root systems were found to be essentially alike; that is, they were mycorrhizal with moniliform „beads“ that were formed mostly as lateral branches on elongated rootlets, and there were not so many of the „necklace chains“. The rootlets, having over-wintered, were dark in color and often appeared dead: under the microscope they were seen to have a silvery coating of mycelium; and that they were not dead was proved by their production of renewed growth, for new little monilar beads were formed upon them.

A new growth of young rootlets is shown in fig. 40: the elongate side-branches as well as the extending rootlets were white, and the surface appeared netted, due to the mycelial investment; while occasional floccose masses of mycelium could be seen. There were protruberant tips of new growth which showed that even in a new system of recently formed rootlets the growth was not steady but intermittent. Setae were few and

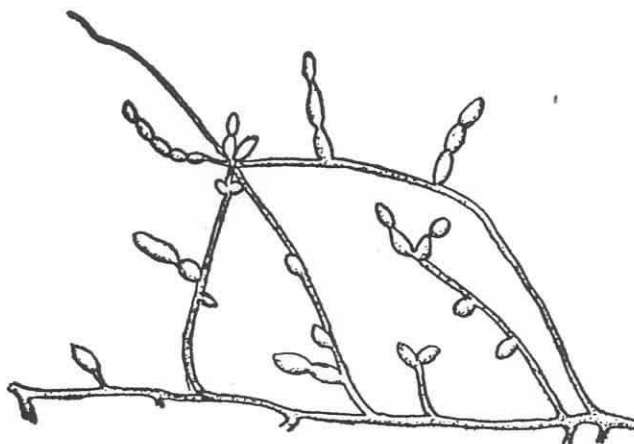
there were no root-hairs. An older system of rootlets is shown in fig. 39 where the short-roots are generally turned into monilae, sometimes laterally, sometimes apically. Many of the monilae were brown stalked (fig. 47). The rootlets were silvery throughout with a welldeveloped mycelium that covered them.



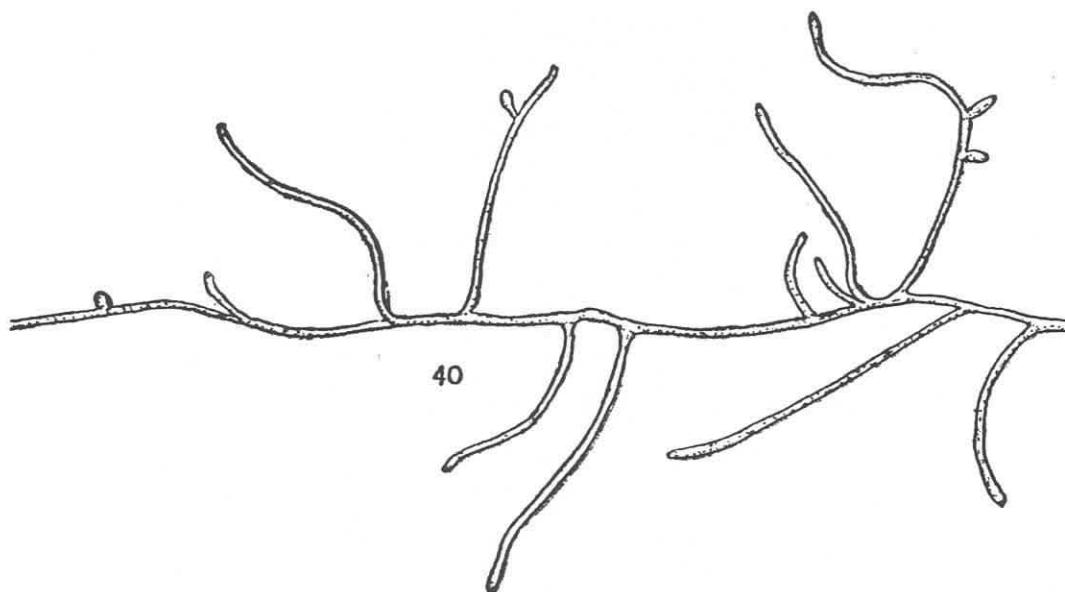
Swamp Maple in Georgia

A page of figured short-roots and their tips is shown. In fig. 43 there is a tubercle with new growth just starting at the apical end. Fig. 41 is from a very setose preparation, and it also shows new growth commencing, as does fig. 42 also. This last short-root was about 1,25 mm long and its surface was netted with mycelium. In fig. 44 a cluster of short-roots is

shown, with setae at apical end (a usual mode of formation, and the cluster coated with floccose mycelium. Figs. 45—46 show unhealthy mycorrhizae with the terminal portion distorted and atrophied, due probably to unfavorable conditions. In the field it was noted that the site from which these



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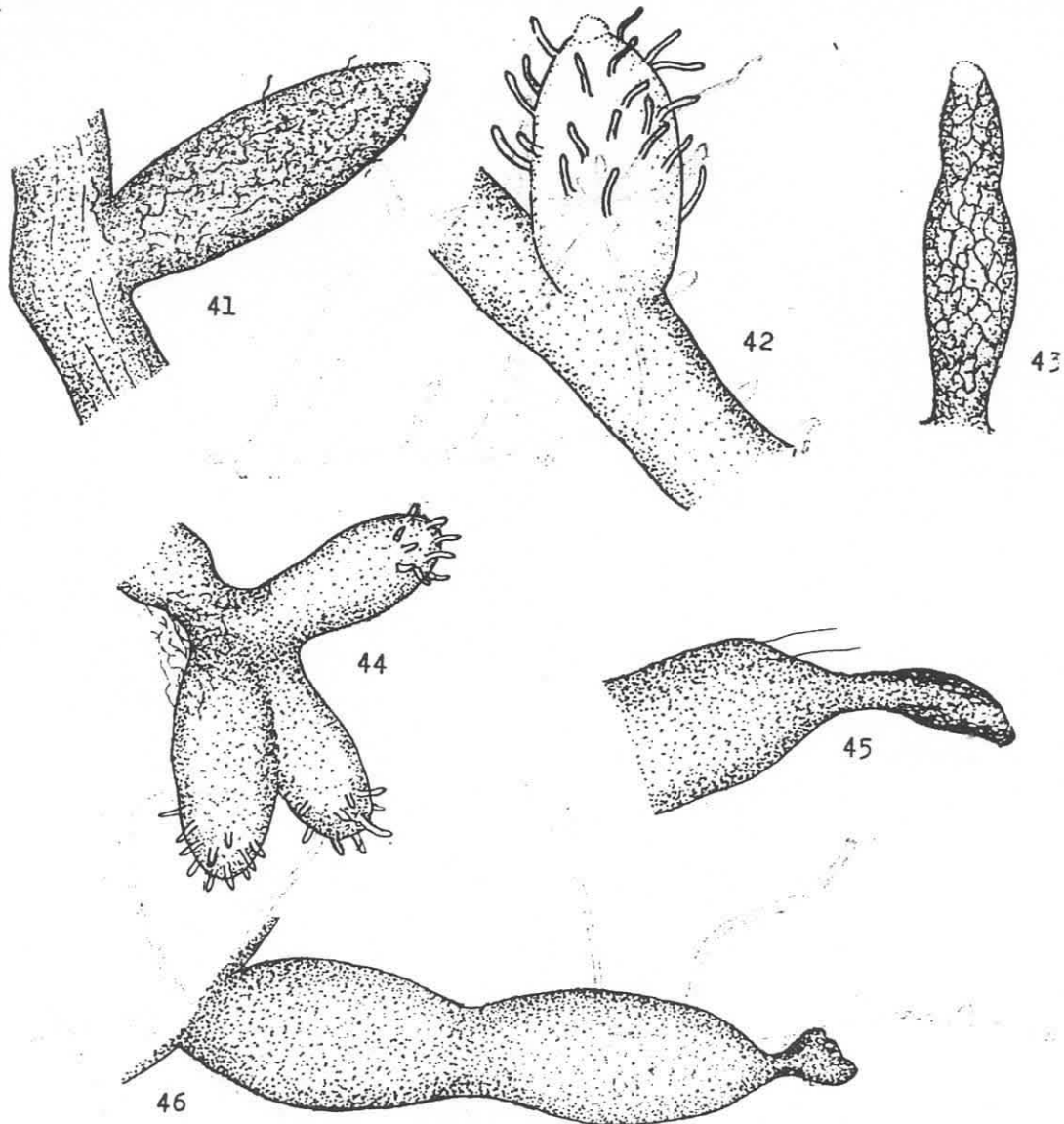
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Swamp Maple in West Florida

short-roots came was too wet, being close to a brook; for, although called a „swamp maple“, it cannot live under strictly anerobic conditions.

In wet pinelands of the Appalachicola National Forest, a solitary small tree of swamp maple was found in flower on January 23. Its root system consisted of rather elongated mycorrhizal short-roots on roots of extension, in most cases the beads being much elongate and thus similar to the New

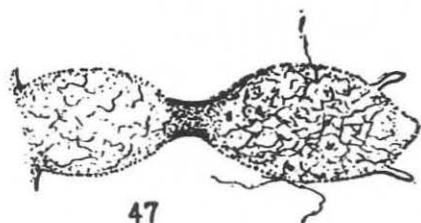
Jersey material and that of the Eastern Shore. The mycorrhiza shown in fig. 48 is typical of the maples generally. Renewed growth was obvious, and a chain of five beads (fig. 52) indicates that the growth may be renewed a number of times. These rootlets, coming from flat wet pine land,



Swamp Maple in West Florida

were more translucent than those of Gadsden County and the central cylinder could be seen in them (fig. 50). Setae were present on the mycorrhizal tips; while older roots were covered with papillae (fig. 49). Such coatings of papillae were also characteristic of older roots of Swamp maple collected in a „magnolia bay“ (swamp) of Calhoun County, near the Chipeola River. Here again the mycorrhizae were elongate (fig. 51), resulting apparently from growth in wet soil. Renewed growth and chains of beads were found in this Calhoun material.

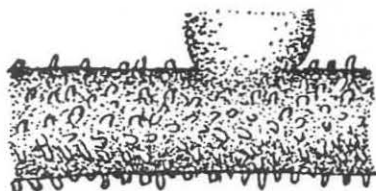
Swamp Maple in the Everglades. About 500 miles south-east, of the West Florida lands where I was encamped are the Everglades. This



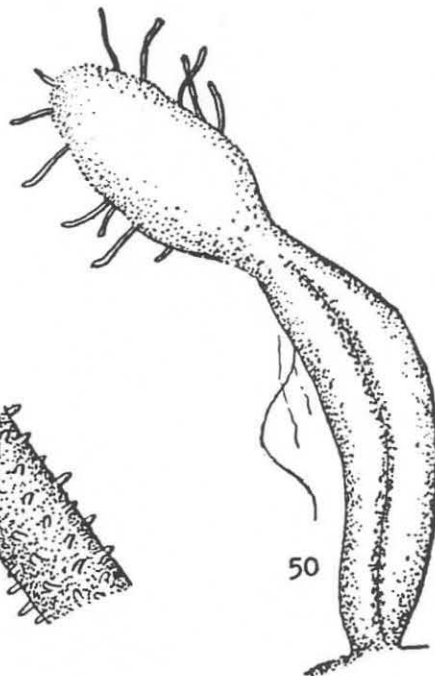
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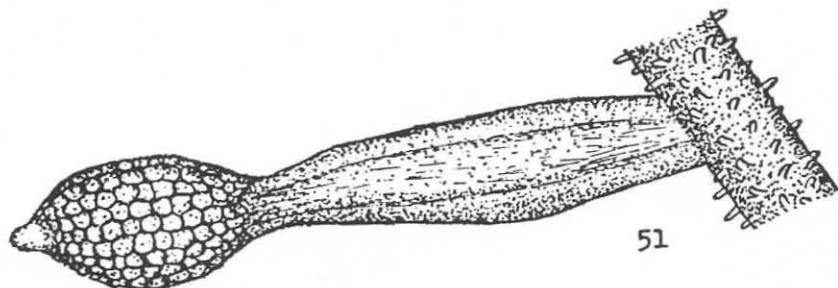
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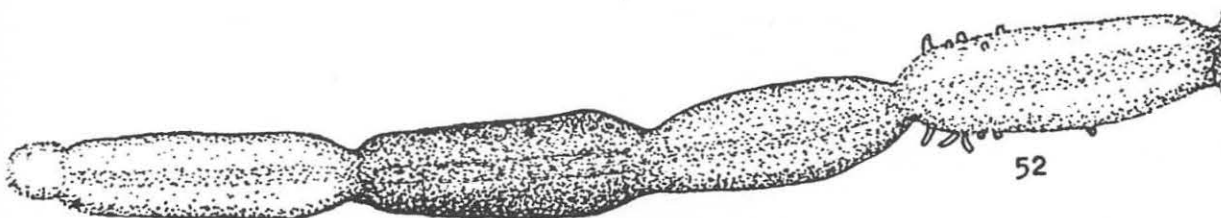
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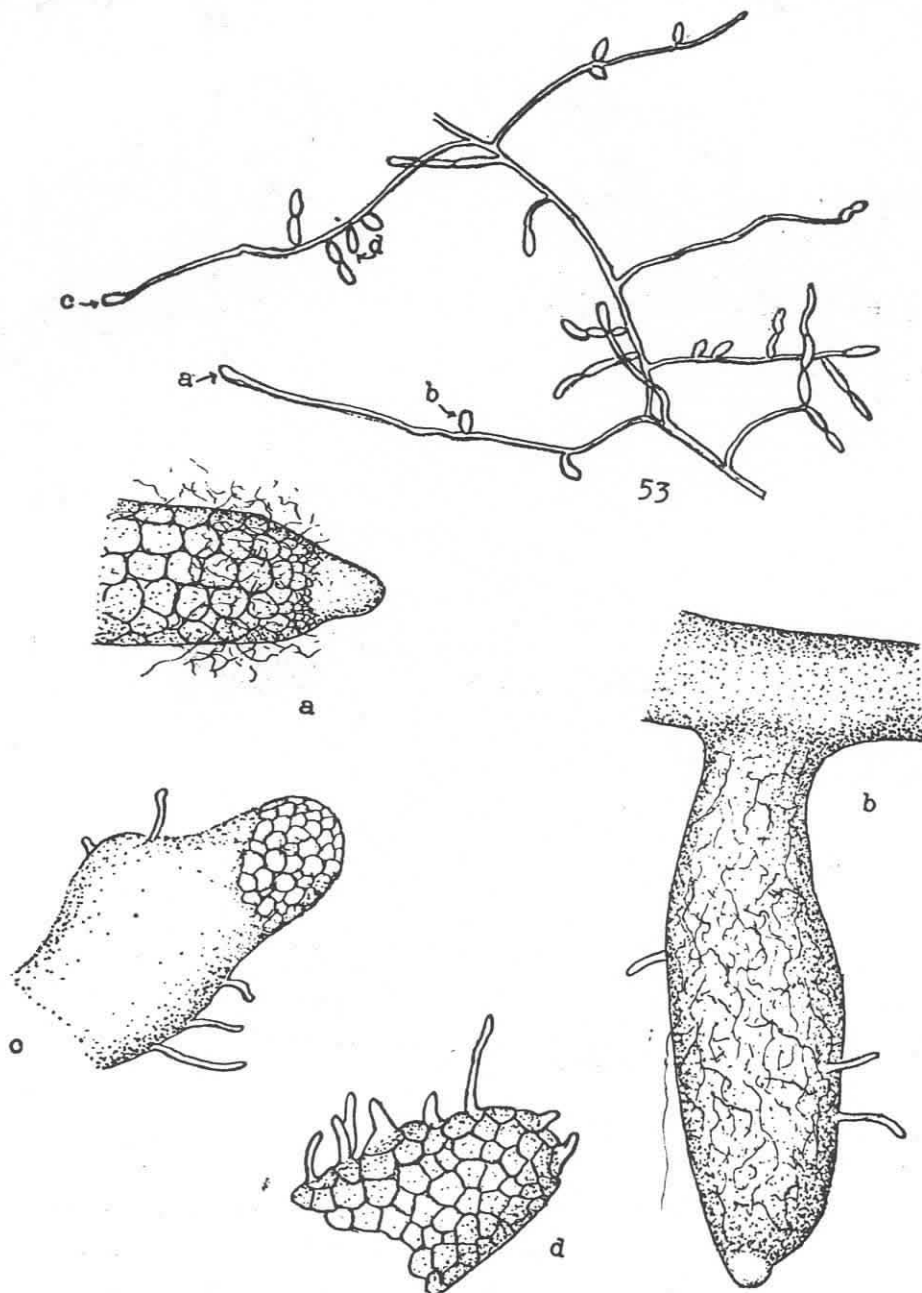
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Swamp Maple in West Florida

name is applied indiscriminately to the Everglades proper, which consist of a grassy marsh devoid of trees and lying on the eastern side of the Florida Peninsula, and the Big Cypress Swamp which is on the western side of the Peninsula. The „Big“ refers to the size of the swamp and not of the trees, which are small. About 30 years ago the Everglades (using the term generally) were drained, which proved a most unwise measure.

While driving from Everglades (City) to Immokalee, I stopped by the wayside and gathered rootlets of Swamp maple, a small tree readily pulling out of the swamp muck, and portions of the matted roots were detached. The root-system, as seen in fig. 53, was of characteristic moniliform, with lateral and terminal monilae, these being rather inclined to elongation. Renewed growth was evident, not only in chains of monilae but in white

66 tips. Setae were rather sparse, and mostly confined to the apical region. It might be mentioned that swamp maple in the Big Cypress Swamy and about Ft. Bassinger, 150 further north, was generally in bloom at this date, which was January 20, 1956.

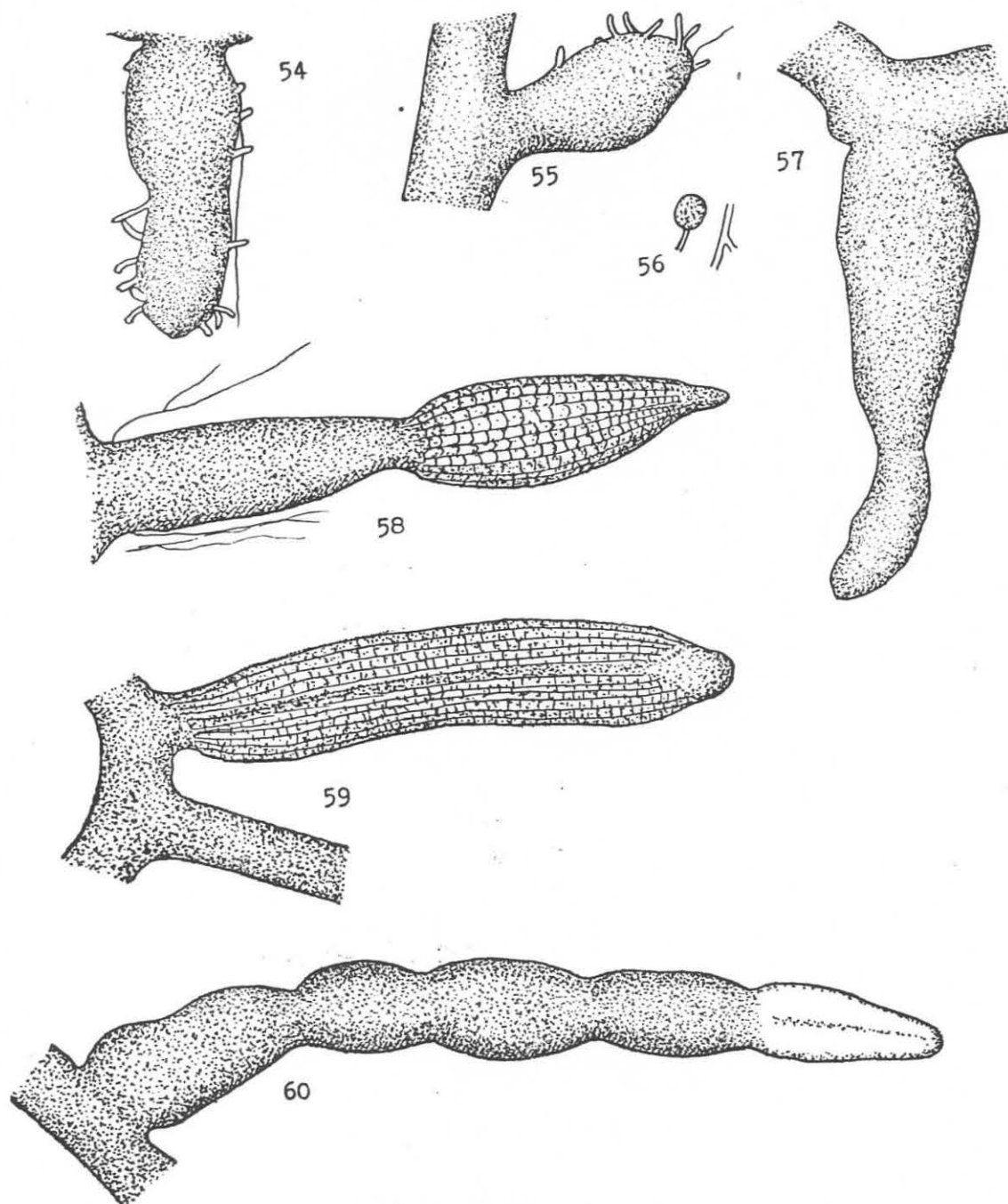


Swamp Maple in South Florida

A STUDY OF ROOT-ENDINGS IN RED MAPLE

Red Maple in Pennsylvania. Red maple is a common tree, abundant in secondgrowth woodlands and coming up abundantly on untilld fields. It is more adaptable than some other native trees, growing well on upland and lowland, in woods and solitarily in fields. It can endure much drought in summer, if normally growing on dry land, but will die

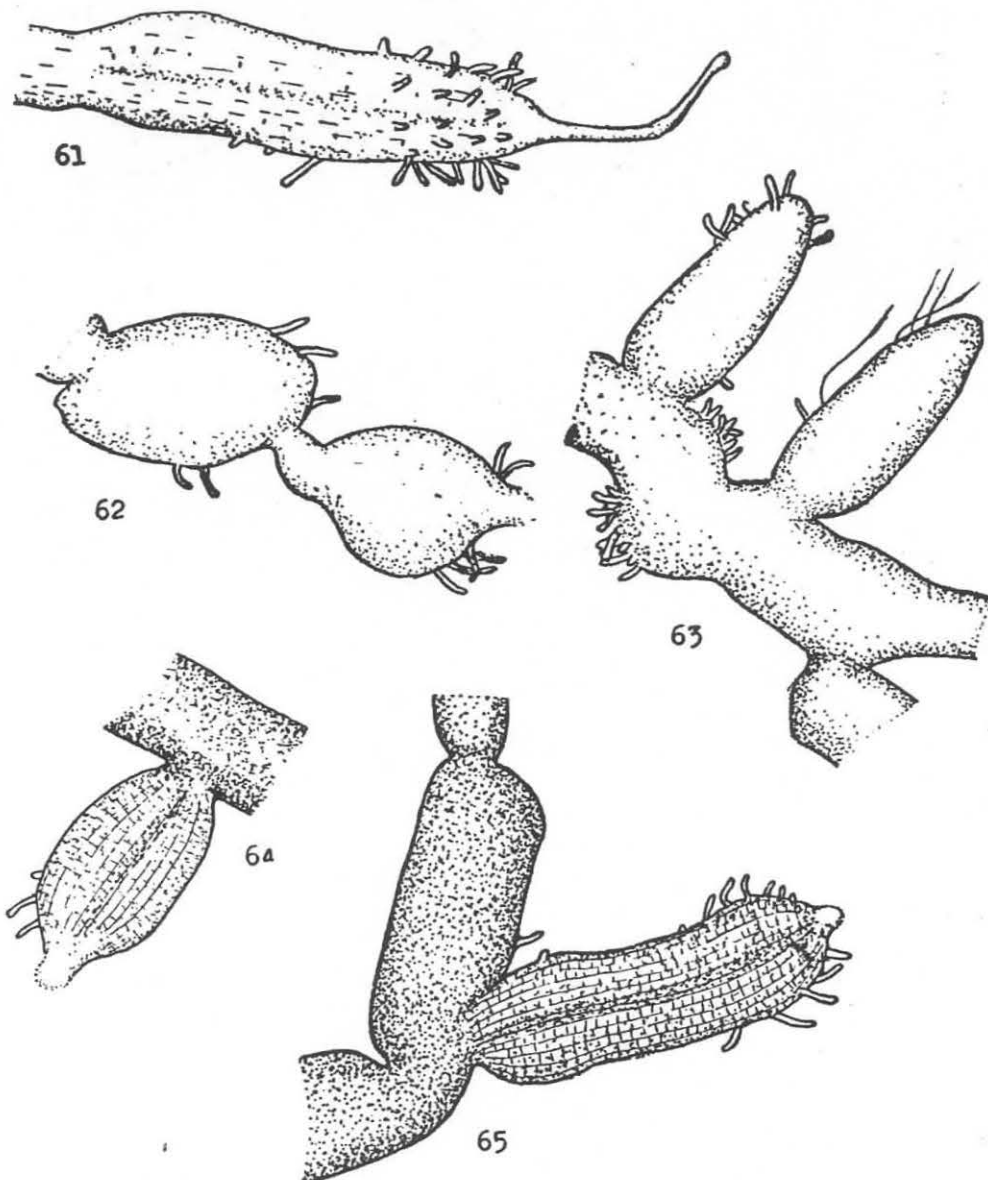
if dessicated after being accustomed to having much moisture — probably in the latter case because the rootlets have been formed near the surface of the soil. It can also grow on flat lands that are wet or even covered with water in a rainy season; but it cannot thrive in soil that is permanently swampy.



Red Maple in Pennsylvania

For this study, material was collected from various sites. One site was the cinder of a former railroad roadbed; and a small tree was growing here thriftily. It had the usual maple mycorrhizae; but under the scope it was seen that, on account of the dry habitat, the branches were short and there were unusual developments: There were distorted tips (fig. 61)

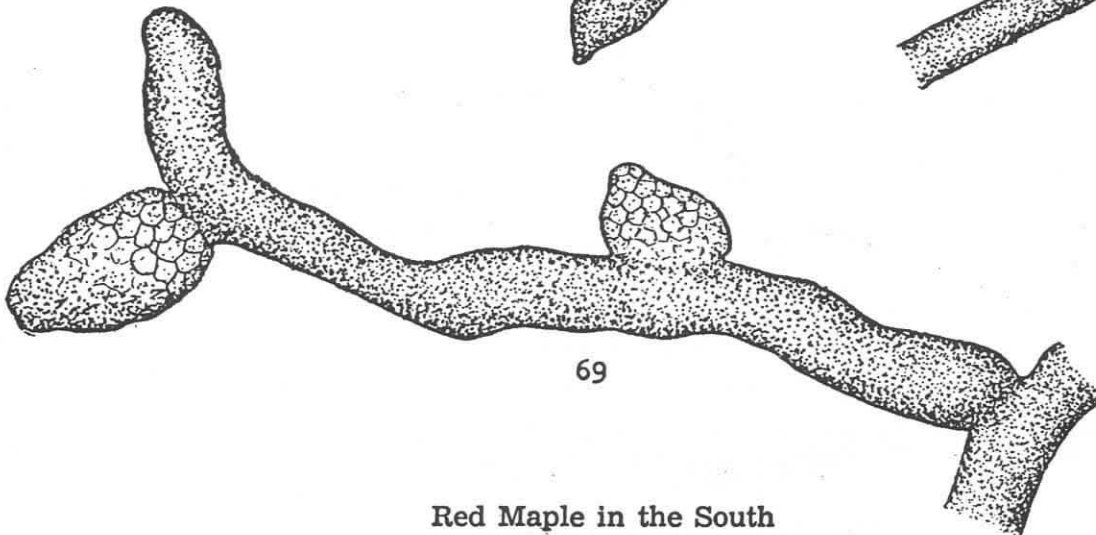
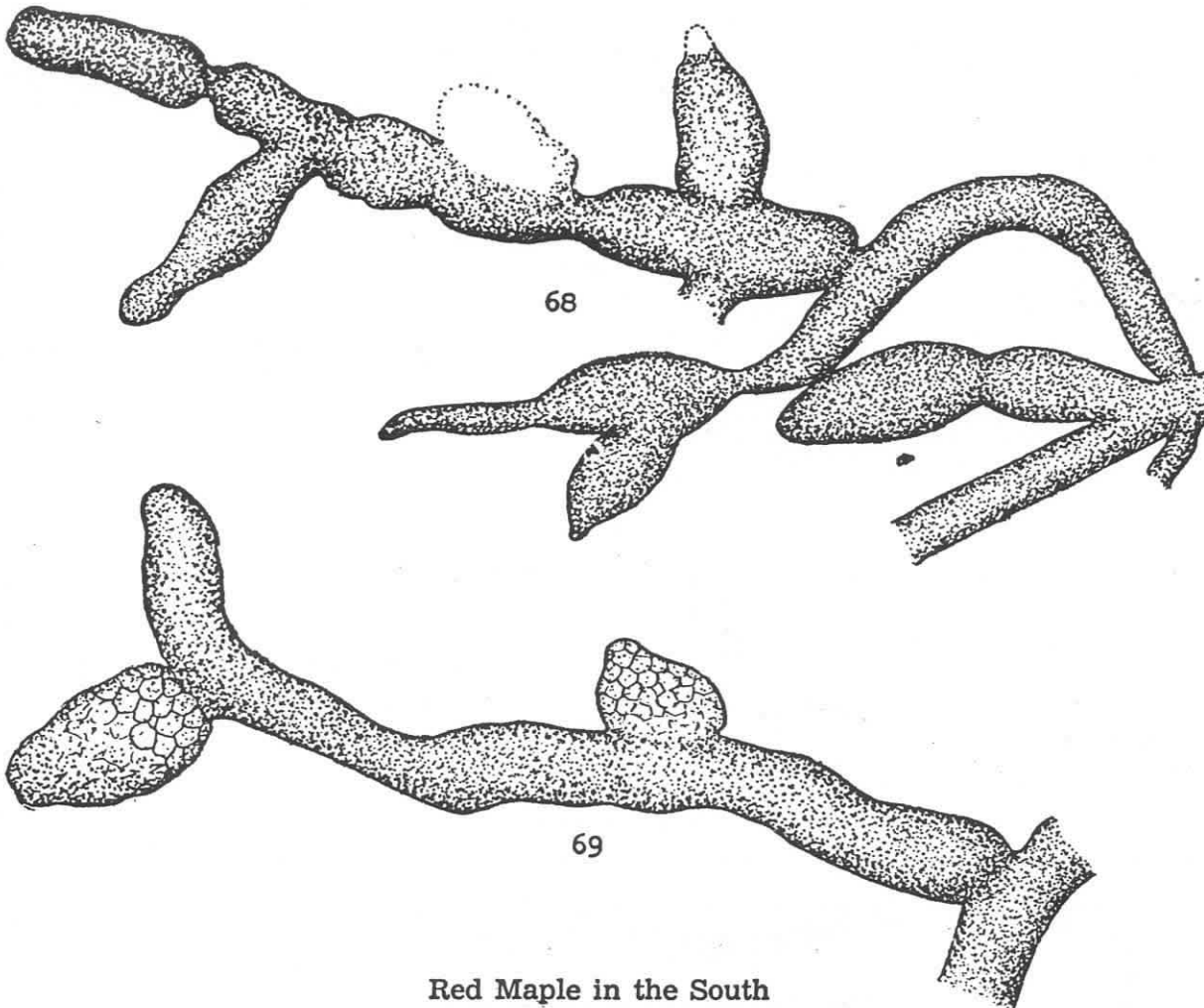
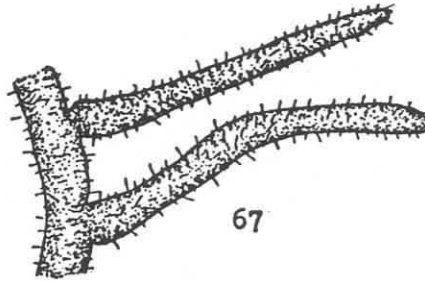
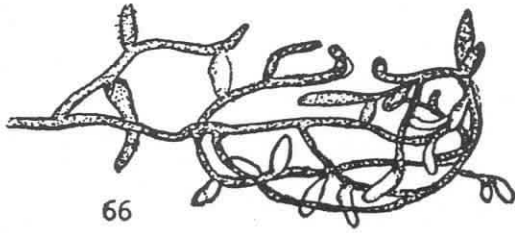
and curious monilae (fig. 62). Renewed growth was present (figs. 64—65), with new tissue protruded at the apex in each case. Setae were commonly produced (figs. 61—65) and, as usual, were formed mostly toward the apex; but they were found on the rootlet also (fig. 63). The short-roots were mostly translucent and showed the central cylinder as a darker strand running through the rootlet.



Red Maple in Pennsylvania

By way of contrast is shown a plate of figures (54—60) drawn from material taken from a lowland site, the trees standing on low flat ground that is always moist and in the springtime is often covered with standing water. The roots are produced superficially, spreading horizontally at the surface in a black muck or mold, and not penetrating freely into the heavy blue and yellow clay beneath. The rootlets respond to this environment by producing short-roots that are elongated and rather attenuate, and setae are not so commonly produced: this form of mycorrhiza is commonly

produced in moist sites. They are translucent when young and show cellular character of the tissues, with obvious apical area of dividing cells; and renewed appical growth is evidenced by the chain of beads that is produced. In fig. 56 is shown a fruiting body of a fungus commonly met in these preparations.

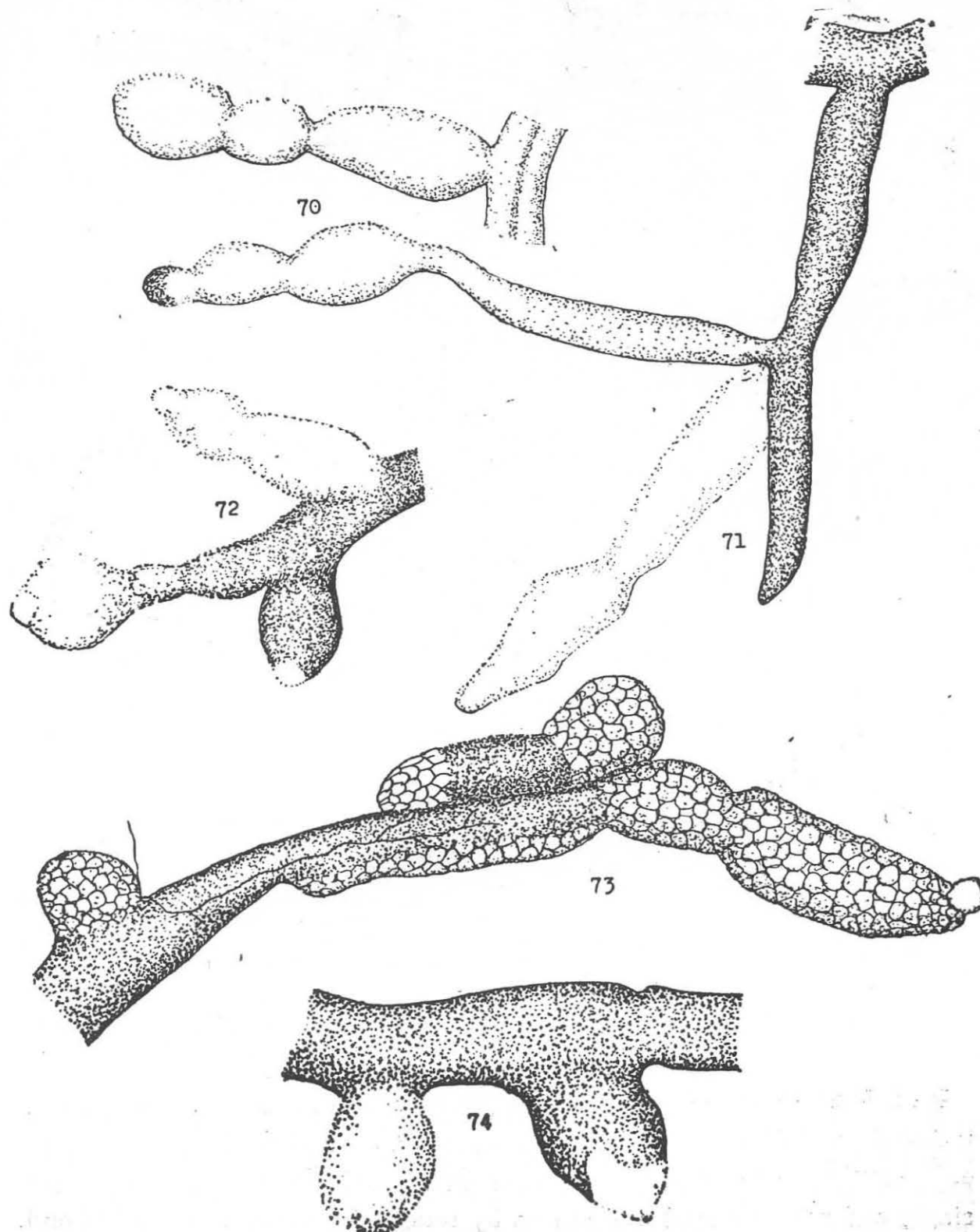


Red Maple in the South

Red Maple in the South. Rootlets of red maple from the Johns Hopkins University woods, on the campus in Baltimore, are shown in figs. 66—67. They show moniliform short branches that are produced singly and not increased into chains by renewed growth. The rootlets and short-roots are richly coated with setae (cf. fig. 67), which is another

evidence that the material came from a dry site; for the soil of these woods is light and friable (derived from gneiss), and not water retentive. (These drawings were made at a low magnification).

Soil in the George Washington National Forest of Augusta County, Virginia, was found to be poor and very dry in early September, 1957. Steep ridges of slate beyond Buffalo Gap were dry as tinder and there



Red Maple in the South

was the merest trickle of water in water courses. The rootlets of red maple collected here were distorted by their growth in an unfavorable clay soil (fig. 68); but nevertheless showed renewed growth in the form of lateral white short-roots.

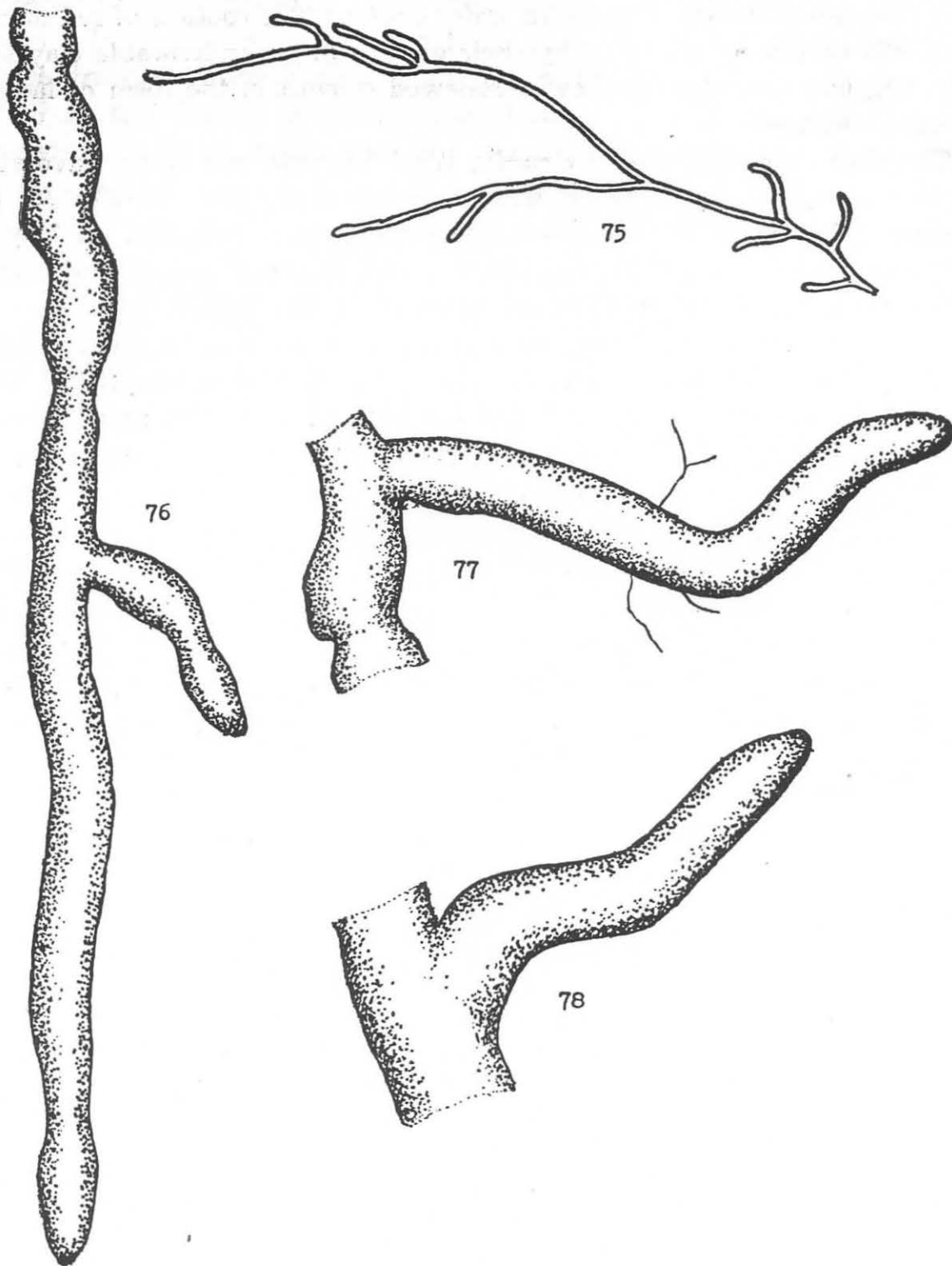
The clay soils of Berkeley County, West Virginia, are also unfavorable to tree growth, and the forest trees here obviously grow slowly. In the Sleepy Creek State Forest, red maple rootlets were collected on May 5, 1957; and were found to be moniliform, with renewed growth and chains of beads: but the rootlets were not setose (figs. 70—72).

A still heavier and stiffer red clay was found to occur in Randolph County, North Carolina, where, on a rainy last day of January, 1957, Red maple rootlets were collected from a woodland tree. The rootlets were moniliform and formed of chains of beads (fig. 73), and there was considerable new growth in evidence. This growth was translucent and showed its cellular structure; and there was a general turgescence of the tissues, resulting from growth in the heavy clay soil. Breaking of the mycoderm and extrusion of new growth is shown in fig. 74. While floccose mycelium was found, the short-roots were not setose.

Red maple from South Carolina was also studied from clay soil, found in the hills of Union County in January, 1957. This clay was somewhat lighter in texture and better drained than that of the North Carolina site just described; and the rootlets illustrated (fig. 69) are nearer „normal“ in form. They are moniliform and show intermittent growth; and there was also considerable new growth in evidence at this season. Alas for duHamel and later students who have been so sure that mycorrhizae are annual productions! Setae were lacking in this South Carolina material.

A STUDY OF ROOT-ENDINGS IN DOGWOOD

Dogwood in New Jersey. Rootlets of this *Cornus* were collected at Pierce's, Cape May County, on August 29, 1929: they were of the simple type characteristic of the species, but were short-branched and almost tubercle-like in their appearance because the branches were rather numerous, short and jointed. The apex was acute or apiculate, as customary in dogwood. The surface was covered with evident mycelium, rather diffusely grown and not formed into a mycoderm; and setae were not well defined. Examined microscopically, it was seen that there were loose, heavy hyphae on the exterior, brown in color, septate and geniculate in structure; and in places they formed a stroma on the cuticularized epidermis. Hyphae apparently entered the epidermis and crossed the cells directly, and not intercellularly. In the cortex the hyphae branched freely, filling a majority of the cells with either skein-like hyphae or with an

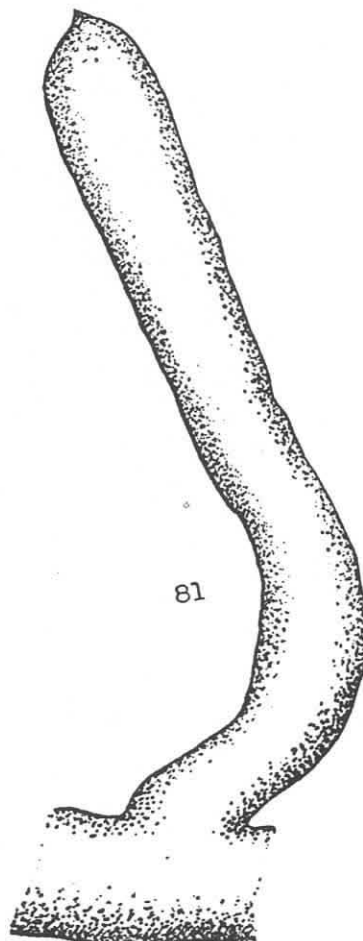
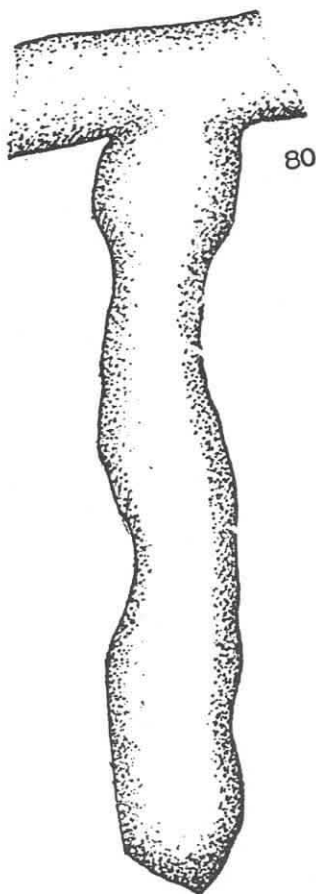
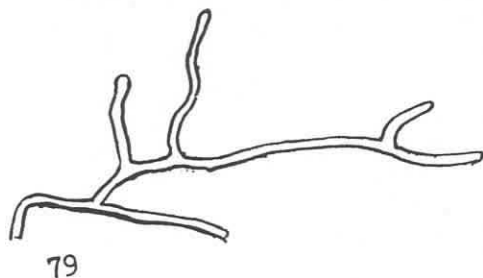


Dogwood in Pennsylvania

hazily stained mass. Frequently one saw enlarged bodies like cysts in the cortical cells, densely staining bodies that were apparently vesicles. They were filled with what appeared to be protoplasmic material and appeared as merely the enlarged end of an hypha, and they were not cut off by a cross-wall.

Dogwood in Pennsylvania. Dogwood is a very common tree that grows on dry or moist soil, in the woods or in the open; but it prefers

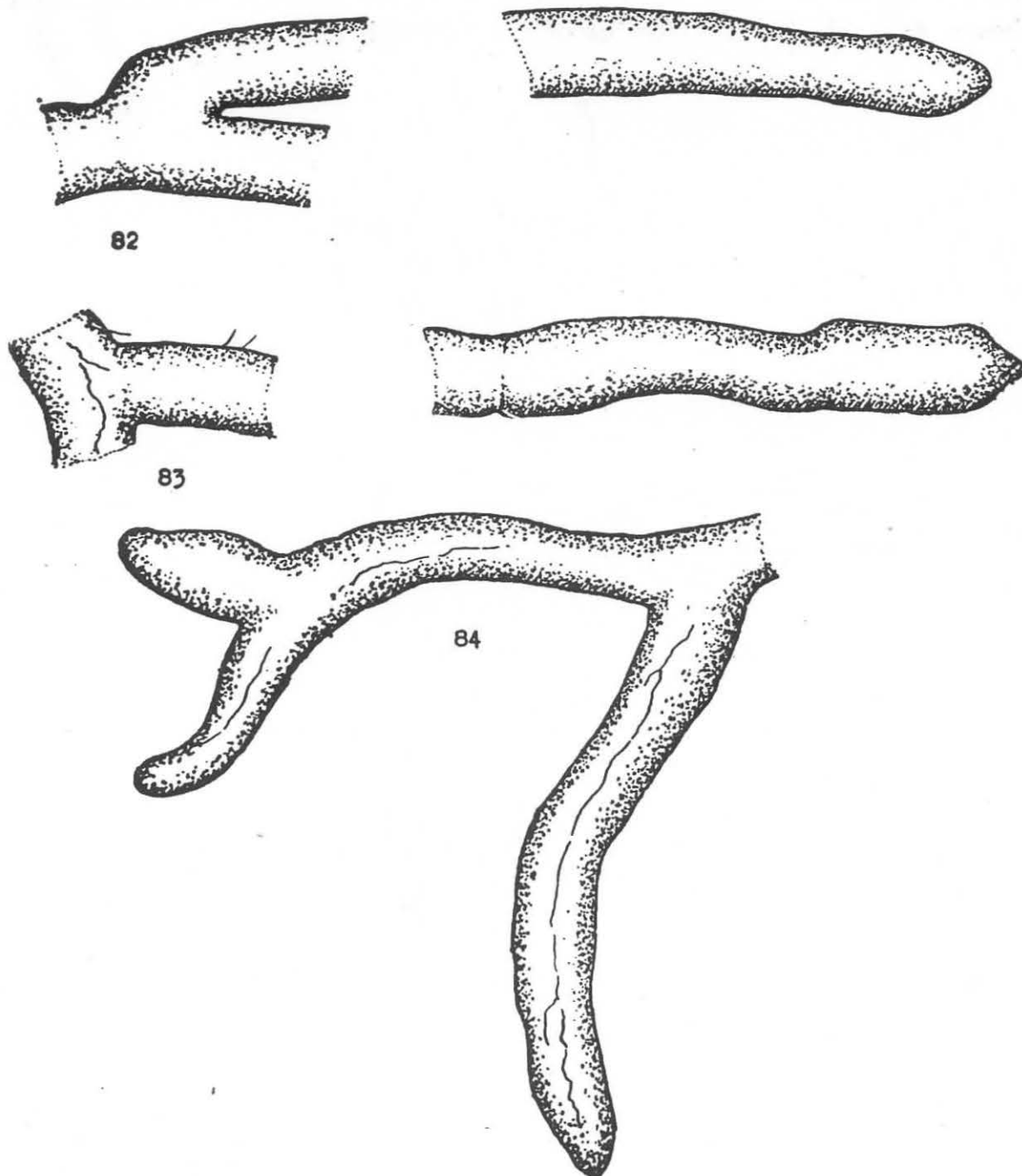
a rich humus soil in full sunlight. It cannot grow in wet land; and in full shade it dwindles and dies: it is prolific and comes up abundantly on untilled fields, the seeds being distributed by birds (especially robins) that feed on the red fruits in October. The drawings (figs. 75—78) were made from material collected from young trees growing in the open, on gneissic soil in Chester County. The habit of growth and manner of branching are shown, as well as the character of the mycorrhizae.



Dogwood in Maryland

Dogwood in Maryland. Dogwood as found in the hills is essentially the same as that of Pennsylvania; but in sandy coastal soils of the Eastern Shore the growth is not as luxuriant. However, the structure of the rootlets and their manner of branching are about the same as those

already illustrated. Dogwood is not modified in structure by sandy soils as it is by clay. These rootlets (figs. 79—91) were collected and studied on April 12, 1957, in Worcester County and in the Pocomoke State Forest. It was cold snowy weather, and spring growth had not commenced.

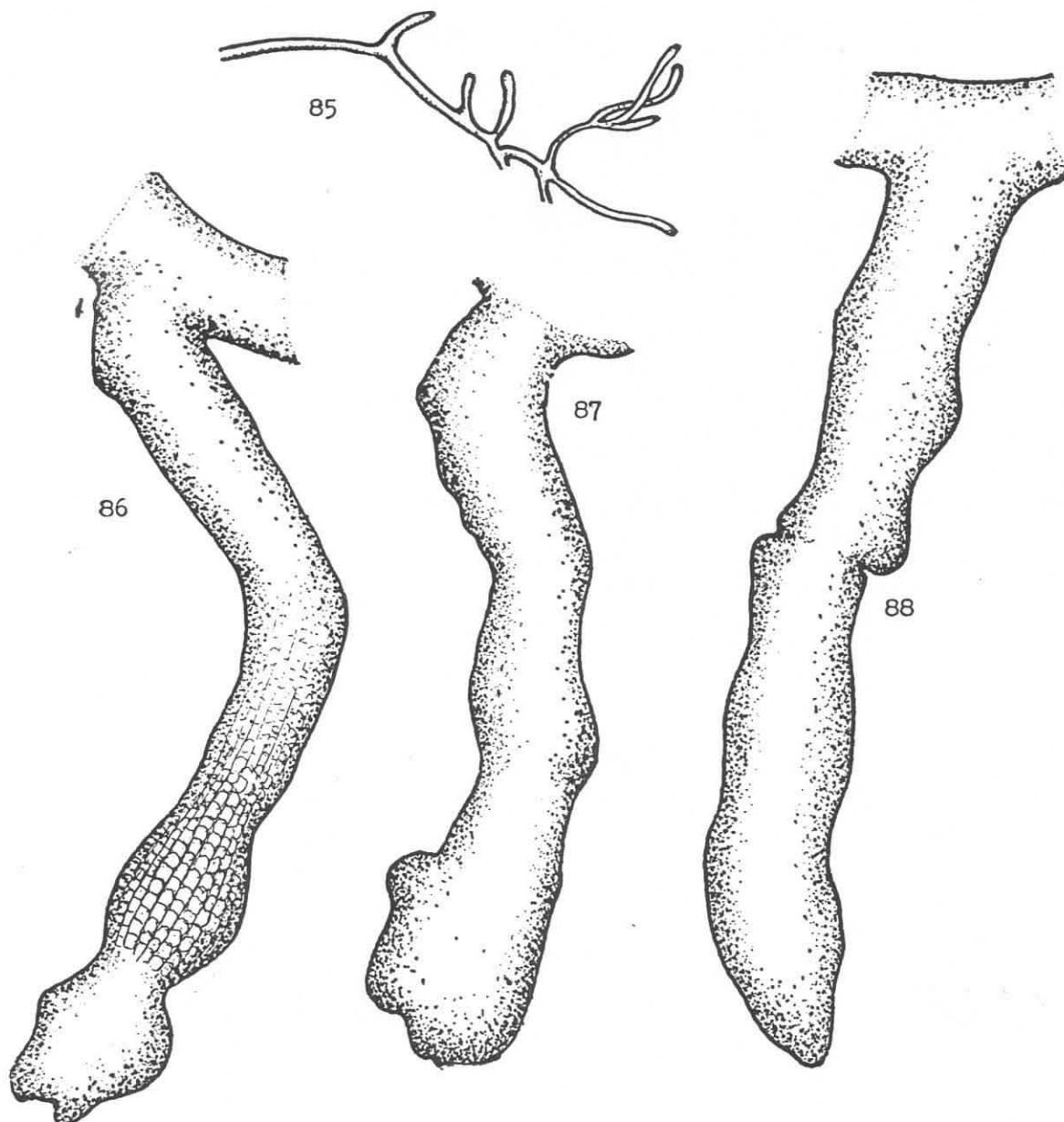


Dogwood in West Virginia

Dogwood in West Virginia. Dogwood is common throughout the mountain area, growing especially in ravines and on moister soil. The material illustrated (figs. 82—84) was collected in Sleepy Creek State Forest on May 20, 1957. It shows the usual branching, the pointed or apiculate end of the mycorrhiza, and evident mycelium on the surface.

The soils here were poor and growth was naturally slow, hence the „jointed“ structure evident in fig. 83, the result probably of retarded growth.

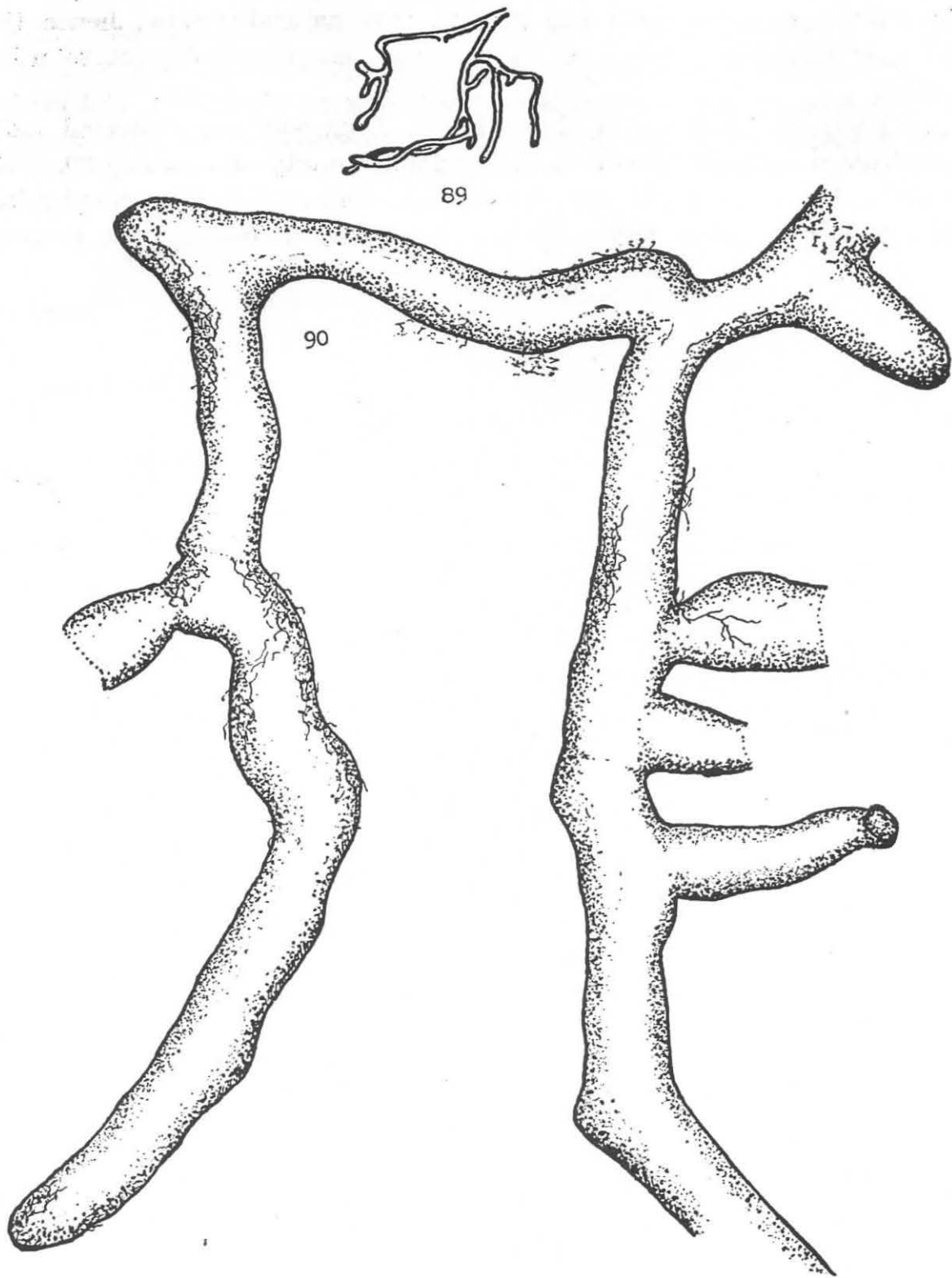
Dogwood in North Carolina. Dogwood was collected from a roadside woods near a stream in Randolph County on January 30, 1957. As the soil was a stiff red clay, the rootlets were modified by the physical difficulties of growth, hence the curious enlargements and the unusual



Dogwood in North Carolina

apices (figs. 85—87), although some „normal“ root-tips were seen (fig. 88). Jointed structure is again apparent, the plants having a difficult time in this red clay; and it is remarkable that so much forest is found upon it.

Dogwood in South Carolina. Dogwood was studied from material collected in a ravine of an abandoned and badly eroded field

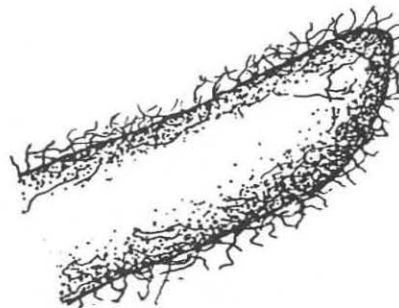
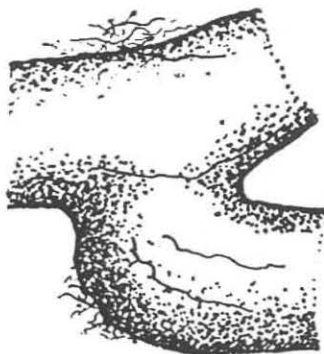
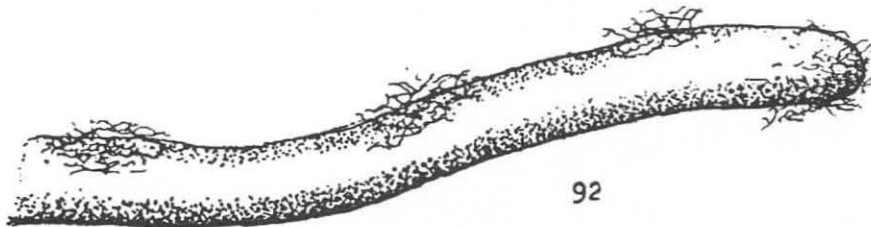
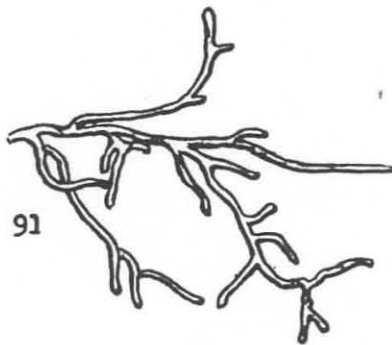


Dogwood in South Carolina

in Union County on January 30, 1957. Being red clay, the soil was a difficult medium for growth of the rootlets; nevertheless they have more or less the „normal“ form and structure (figs. 89—90). There is evident mycelium on the surface of these mycorrhizae which holds clay particles.

Dogwood in Georgia. Dogwood was studied on January 29, 1957, in Quitman County. The material was collected from a lowland near

a stream and, while the soil was clay, it was not so stiff as to cause marked hypertrophy. The rootlets show (figs. 91—93) the usual dogwood characters, and were well coated with mycelium, which held clay particles enmeshed in the hyphal tangle. Dogwood was here part of the Southern coastal flora.

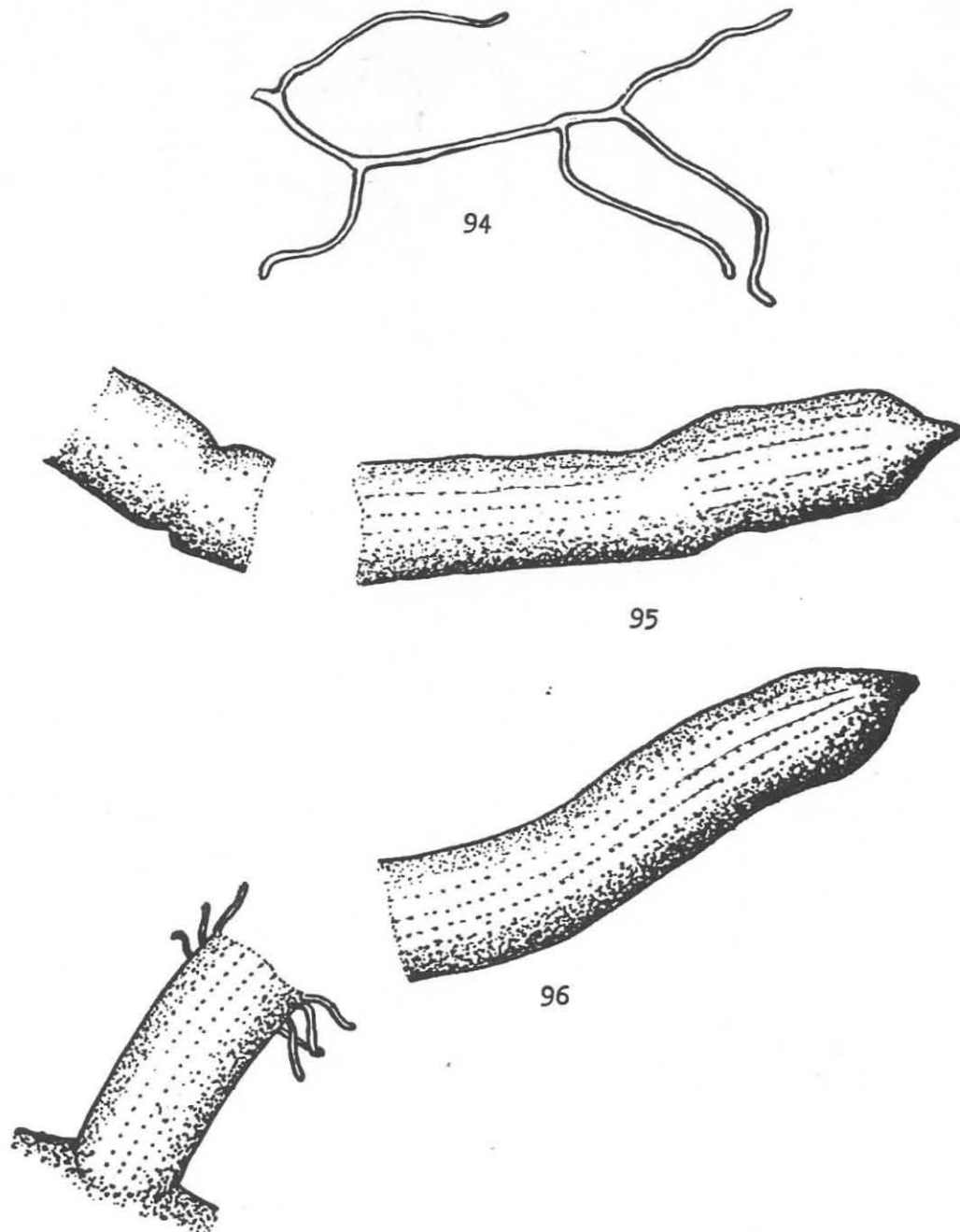


Dogwood in Georgia

Dogwood in Alabama. The southeastern corner of Alabama is Houston County; and it was in a roadside woods in the midst of this County that the material illustrated (figs. 94—96) was collected. This material is much the same as that described and figured above, but two features were different; the rootlets inclined to translucence and showing of their cellular structure; and there was presence of hair-like structures (fig. 96) which may or may not have been true hairs. This material came

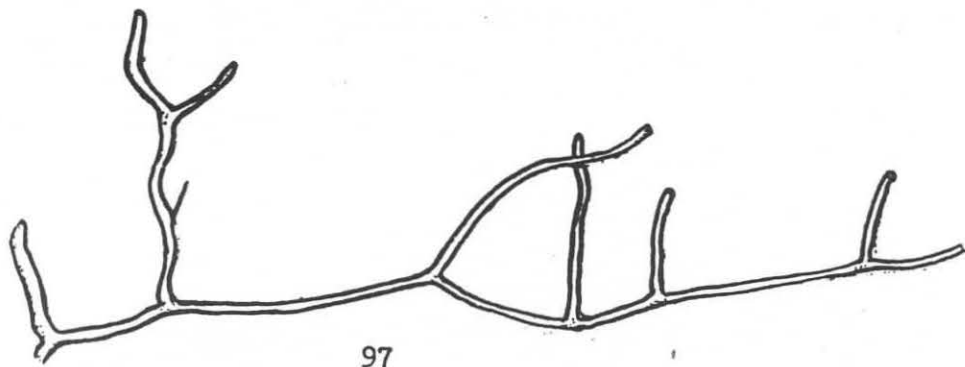
from a sandy loam of the (Gulf) coastal province; and the soil was normally moist.

Dogwood in West Florida. Dogwood is scattered in the wooded hills of Gadsden County, and has a depauperate appearance to one who is accustomed to this species in the north. For here the soil is not a deep rich loam but a sandy loam overlying a stiff yellow clay, with calcareous

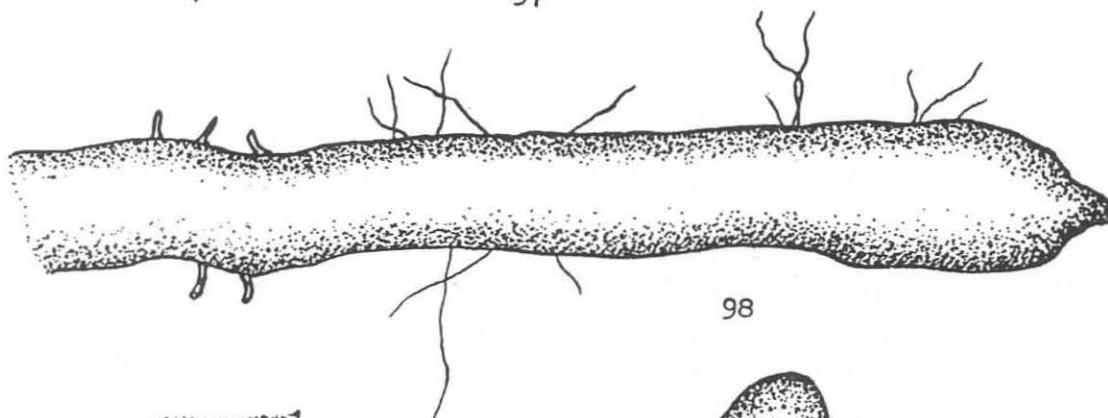


Dogwood in Alabama

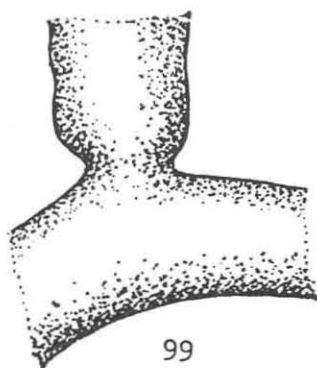
bedrock beneath. The rootlets (figs. 97—101) show a heavier structure but the usual dogwood form. However, there were some „hairs“ present, just as in the Alabama material; and these may be characteristic of the rootlets when grown in moist sand,



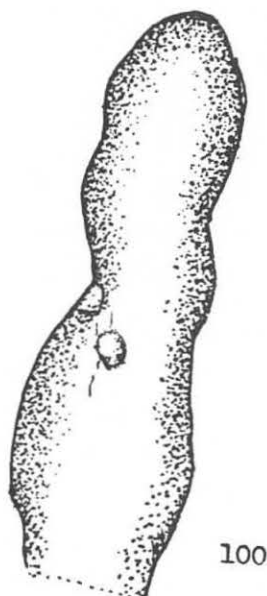
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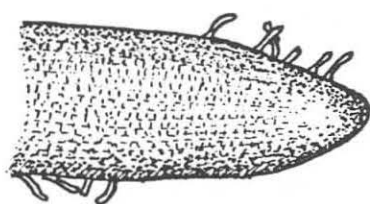
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Dogwood in West Florida

CONCLUSIONS

Mycorrhizae. It is so evident that it scarcely needs to be said, that the rootlets of the trees considered in this paper are normally mycorrhizal. In every tree sampled, from the frigid mountains of Vermont to the warm sands of Florida, there were found these fungal short-roots. Hence, the nutrition of beech, maple and dogwood is certainly mycotrophic and not autotrophic through root-hairs. There is no point, therefore, in

speaking of root-hairs in connection with these trees as though they were the normal structures and mycorrhizae exceptional: mycorrhizae are the normal root-structures for intake of materials and mycotrophy is the normal mode of nutrition in these trees.

This is not the place to recount it, but my studies show that practically all trees of the eastern U. S. A. are mycotrophic and not autotrophic. Also, most shrubs and herbs lack root-hairs, although they are not necessarily mycotrophic in consequence: thus, the *Araceae* (as far as I have examined them) all lack root-hairs, although I do not think they are mycotrophic. Why, then, speak of root-hairs as „normal structures“, and root-hair plants as „typical plants“? Actually, they are atypical.

If we admit these facts, as admit them we must unless we prove nature a liar, it means a revolution in Plant Science. No longer can General Botany be taught to undergraduates by way of the „typical root-hair plant“; and elementary text-books, being built on the „typical root-hair plant“ must be discarded. Further, Plant Physiology needs a complete revision to bring it in accord with the fact that mycotrophic nutrition prevails over root-hair nutrition. And, as a corollary, governmental „experiment stations“ can spend new millions in studying mycotrophy. Moreover, Systematic Botany must awaken to the fact that no plant description is complete that omits a description of the root. The roots are certainly as important as any other organs of the plant; and rootlets are extremely characteristic in structure. Every genus has its own root-form; and one can identify a plant, at least to family or genus, from examination of the rootlets. As an illustration: On a Florida hillslope I found a small puzzling shrub which had attenuate yellow branchlets strung with tiny green leaves that immediately suggested the specific name of „*microphylla*“: but what was the genus? Examining the rootlets under the scope, I decided that they must belong to a *Ceanothus*; and going back to the hillslope, I hunted about until some fruiting branches were discovered, and they bore typical *Ceanothus* capsules. *Ceanothus microphylla* was the shrub.

The roots are „conservative“, for they are less exposed to fluctuating external conditions than the aerial organs. Each group of plants preserves its own rootlet form — simple, coralloid, betuloid, root-hair, etc.; — and the characters are not only generic but appertain to families. Thus all *Fagaceae* are mycorrhizal while all *Cruciferae* (as far as I have studied them) possess root-hairs. Through root-study it is possible to correct mistakes of Taxonomy. Thus, the *Sarraceniaceae* and the *Droseraceae* are placed in the order *Sarraceniales*; yet the two families have really nothing much in common except a carnivorous habit; and their roots prove that the two families cannot be united, for all *Droseras* possess an abundance of root-hairs, while all *Sarracenias* lack these structures.

Since few if any plants have been accorded an adequate description of their roots, here is a virgin field for some budding Linnaeus. Every vascular plant should be redescribed so that the important root-structure shall be given its rightful place; and of course in the process of description there must be a new name, with the describer's own name attached!

The vascular plant Dominant. In all cases it is the vascular plant that determines the form of the root-ending. The fungal „partner“ doubtless incites the formation of an hypertrophic structure, but aside from providing the stimulus, it seems to have little to do with formation of the mycorrhiza, which is always and everywhere essentially the same in form and structure for a given „species“. As to the relation of the fungus to mycorrhizal color, that is another question.

Since the fungus plays a secondary part in the relationship, it would seem that less attention need be paid to it. To determine what fungus is concerned, it must be isolated; and as others have ably pointed out, it is difficult to isolate the truly mycorrhizal fungus; that is, the one that gave initial impulse to enlargement of the vascular plant tissues. And synthesis of fungus and sterile (?) root to form a mycorrhiza is not necessarily conclusive that particular fungus always forms that particular sort of mycorrhiza in all countries, under all conditions of soil and climate. Moreover, it may be questioned whether the same sort of fungus always forms the mycorrhizae of a particular sort of plant. When one recollects that all the root-endings of a certain sort of tree are always turned into mycorrhizae, in all places: when one contemplates beech, for example, growing in the frozen mountains of Vermont and on the coastal sands of Virginia, in red clay soils of the South and in warm sandy loams of Florida, in glaciated detritus and in unglaciated residuum, it would seem almost a miracle if exactly the same species of fungus followed the vascular plant around faithfully in order charitably to form its mycorrhizae. I have long regarded the mycorrhiza as a casual thing, resulting from the stimulus of a fungus that grows into the root from the soil. The soil-fungi grow through the humus layer of the A horizon and, encountering a root, grow into it as into any other part of the environment; and, being in the root, the irritation of its presence causes the vascular plant to form an hypertrophic growth which is characteristic for that species and is called a mycorrhiza. As to the fungus, it is physico-chemically controlled by the vascular plant; otherwise it becomes a parasite and the vascular plant is injured. I cannot prove my viewpoint; but on the other hand, I do not know that it has ever been disproved.

The effect of soils. In this study the rootlets have been taken from a considerable variety of soils; namely, the glacial detritus of Vermont and New York; the residual soils of the unglaciated States southward; the rich soils of Pennsylvania and the thin soils of West Virginia; the

heavy clay soils of the South and gravels from New Jersey to Florida; and the coastal sands and sandy loams. Yet in all these very different soils the form of the rootlets for any given sort of vascular plant is essentially the same. In other words, soil does not primarily determine the form of the mycorrhiza or rootlet, but the form is determined specifically and hereditarily by the vascular plant. Yet the soil can modify rootlet form: this fact is remarkably shown in the heavy red clay soils of the south, where developing rootlets are physically hampered by heavy unyielding clay while at the same time they are apparently stimulated to renewed branching. Drawings of Georgia and North Carolina rootlets illustrate these points. Again, a moist or wet soil tends to an elongation of the rootlets, to render the texture soft, and to make the tissues translucent. Mycorrhizae are produced in wet soil, but the form tends to attenuation.

The effect of climate. Here again, in regard to the mycorrhizae, we are dealing with heredity of the vascular plant, which causes the plant to produce rootlets of a specific form, whether in a frigid or a sub-tropical climate. But there is some evidence that climate may affect rootlet form, as illustrated in the morphology of West Florida rootlets: for in a warm soil that never freezes, the rootlets tend to grow into odd shapes and of a different structure.

Otherwise climate affects these plants chiefly through drying of the roots, — drying them by freezing in some areas, because the more superficial roots are sure to be killed during winter in more exposed places, sometimes causing death of the plant; drying also by summer drought, as for example, numbers of beech trees were killed in the dry summers of the 1930 s. Climate also affects seedlings, in that they may be frost-heaved out of the ground and thus killed.

As to latitude in relation to the plants studied, it affects their climate only partially since, as already explained, the climate is largely controlled by air masses that sweep up or down the coast, almost without hindrance.

O KORZENIACH OSTATNIEGO RZĘDU
W SYSTEMACH KORZENIOWYCH BUKA, KLONU I DERENIA,
JAKIE FORMUJĄ SIĘ W GLEBACH
WSCHODNICH STANÓW AMERYKI PÓŁNOCNEJ

Streszczenie

Jednym z problemów badań nad mikotrofizmem jest forma mikoryz. Można się zastanawiać, czy jest ona uzależniona od działalności infekującego grzyba, czy od infekowanej rośliny lub może od współdziałania obu tych czynników specyficznych dla danego środowiska.

Mając na celu wyjaśnienie tych spraw, o ile to w ogóle możliwe, autor przeprowadził badania pewnej ilości mikoryz drzew we wschodnich stanach Ameryki Północnej. Do badań wybrał rodzaje drzew: buk, klon i dereń z dwóch przyczyn, a mianowicie dlatego, że rodzaje te występują wzdłuż atlantyckiej części Ameryki oraz że każdy z tych rodzajów ma wyraźnie różniące się pod względem morfologicznym korzonki krótkie.

Występując wzdłuż całego wybrzeża atlantyckiego Ameryki, drzewa te rosną na bardzo różnych glebach. Występują na zamarzających glebach na północ od falistej linii przechodzącej przez stany: New York, New Jersey i Pensylwanię, oraz na nigdy nie marznących glebach na południu stanów. Na jednych i drugich terenach wyrastają na glebach ubogich i żyznych: na łąkach, glinach, żwirach, piaskach i mułach; na glebach płytkich na skałach jak również na glebach głębokich z wykształconym profilem glebowym. Szczególnie warto zwrócić uwagę na gliny czerwone na południu stanów.

Poza tym trzeba przypomnieć, że ten rozległy zasięg rozciąga się od zimnego klimatu Kanady do podzwrotnikowego klimatu na południowym krańcu Florydy. Na terenie stanu Vermont gleby marzną każdej zimy, gdy tymczasem na Florydzie nigdy nie zamarzają. Na północy gleby są wilgotniejsze, gdy tymczasem na południu są wyschnięte w ciągu długiego lata.

Jednak klimat całego wybrzeża ma pewną cechę wspólną w rozmieszczeniu wiatrów, które na zmianę wieją od zatoki (Gulf) na północ i od Kanady na południe, co trochę wyrównuje różnice położenia geograficznego.

Dokonując wyboru drzew, których zasięg obejmuje ten cały pas po brzeża, autor miał możność pobierania próbek korzeniowych w różnych warunkach glebowych i klimatycznych. Autor nie oznaczył gatunków drzew, ograniczając się do rodzajów, gdyż przekracza to możliwości jednego specjalisty. Dokonał wyboru rodzaju *Fagus* z jego koralowatą mikoryzą, rodzaju *Acer* z jego łańcuszkowatą mikoryzą oraz rodzaju *Cornus* z jego mikoryzą prostą.

Po przedstawieniu swych obserwacji autor wyciąga wniosek, że forma mikoryz jest zależna od rośliny drzewiastej i pozostaje zasadniczo niezmienną bez względu na to, gdzie drzewo wyrasta. Autor poświęca przelotną uwagę symbiotycznemu grzybowi, uważając go za przypadkowego partnera, którego drzewo ogranicza w rozwoju oddziaływaniem osmotycznym. Autor przypisuje korzeniom ostatniego rzędu tę samą wagę w życiu rośliny, co i innym organom, oraz stwierdza, że istniejące opisy roślin są niedostateczne, gdyż prawie zupełnie nie uwzględniają mikoryz.

Co do wpływu gleby na morfologię mikoryz, autor ogranicza swe badania tylko do poziomu A, nie badając mikoryz w różnych poziomach profilu glebowego.

Не заобсервовал он również wyraźniejszych różnic w mikoryzach z gleb zamarzających i niezamarzających. Przypuszcza, że może różnice te wystąpiłyby, gdyby badać mikoryzy z poziomu B.

Natomiast stwierdził on silny wpływ na morfologię mikoryz wywierany przez czerwone gliny w południowych stanach, w których to glinach korzonki krótkie (rootlets) odznaczały się silnym hypertroficznym zgrubieniem.

Mikoryzy w piaskach rozwijały się jako wydłużone i dziwnie źle uformowane korzonki krótkie, których powierzchnia była pokryta obficie szczecinkami (setae).

Mikoryzy rozwijające się w glebach mokrych wyrastały wydłużone i miały budowę bardzo delikatną i przezroczystą.

O wpływie klimatu da się powiedzieć, że w najbardziej północnej części zasięgu mikoryzy rozwijają się tylko w ciągu krótkiego lata, nawet jeszcze w połowie maja nie stwierdzono powstawania mikoryz u buka, gdy tymczasem na południu młode mikoryzy są formowane cały rok bez przerwy.

Między północą i południem istnieje różnica w warunkach pobierania wody. W stanie Vermont w ciągu zimy panuje susza fizjologiczna na skutek zmarznięcia gleby, na południu zaś zimy są deszczowe, przez co stają się sezonami rozwoju, a lata są suche. Można by przypuszczać, że ciekawe uformowanie korzonków ostatniego rzędu, które znaleziono w Zachodniej Florydzie, uwarunkowane jest rozwojem w ciepłej glebie piaszczystej i w ciepłych roztworach glebowych (ground-water).

О КОРНЯХ ПОСЛЕДНЕГО РАЗРЯДА В КОРНЕВЫХ СИСТЕМАХ БУКА, КЛЕНА И КИЗИЛА, КАКИЕ ОБРАЗУЮТСЯ В ПОЧВАХ ВОСТОЧНЫХ ШТАТОВ США

Краткое содержание

Одной из проблем исследований по микотрофизму является форма микориз. Можно обсуждать, зависит ли она от действия инфицирующего гриба, или от инфицированного растения, или, может быть, от содействия этих двух факторов специфических для данной среды.

Автором исследовано с целью разъяснения этих вопросов, если это вообще является возможным, некоторое количество микориз деревьев в восточных штатах США. Автором были избраны для исследований породы деревьев: бук, клен и кизил по двум причинам, а именно потому, что эти породы выступают вдоль атлантической части Америки, а также потому, что каждая из них имеет морфологически разнящиеся короткие корешки.

Выступая вдоль всего атлантического побережья Америки, эти деревья растут на очень различных почвах. Они выступают на промерзающих почвах на север от волнистой линии, проходящей через штаты: Нью Йорк, Нью

Джерсей и Пенсильванию, а также на никогда не промерзающих почвах на юге штатов. На одних и других территориях они произрастают на скудных и урожайных почвах: на илах, глинах, гравиях, песках; на не глубоких почвах на горной породе и на глубоких почвах со сформированным почвенным профилем. Особенно стоит обратить внимание на красные глины на юге штатов.

Кроме того, следует напомнить, что этот обширный ареал простирается от холодного климата Канады по субтропический климат южного края Флориды. На территории штата Вермонт почвы промерзают в каждую зиму, тогда как во Флориде они не промерзают никогда. На севере почвы более влажны, тогда как на юге они сухие в течение долгого лета.

Однако климат всего побережья имеет общую примету в распределении ветров, которые попеременно дуют от залива (Гольф) на север и от Канады на юг, что немного выравнивает географически положенные различия.

Автором избраны деревья, распространение которых охватывает всю прибрежную полосу, что дало возможность отбора корневых образцов в различных почвенных и климатических условиях. Автором не обозначены виды деревьев, так как это превышает возможности одного специалиста и он ограничился их породами. Им избрана порода *Fagus* с ее коралловидной микоризой, порода *Acer* с ее цепочковидной микоризой, а также порода *Cornus* с ее простой микоризой.

После изложения своих наблюдений автором сделан вывод, что форма микориз является зависимой от древовидного растения и остается в основном неизменной, несмотря на то, где произрастает дерево. Автором уделено мимолетное внимание симбиотическому грибу, считая его случайным партнером, развитие которого ограничивается деревом осмотическими процессами. Автором приписывается корням последнего разряда такая же важность в жизни растения как и другим органам и констатировано, что существующие описания растений являются недостаточными, так как они почти совсем не учитывают микориз.

Что касается влияния почвы на морфологию микориз, исследования автора ограничивались только к горизонту А, микоризы в различных уровнях почвенного профиля исследованию не подвергались.

Автором наблюдались также более заметные различия в микоризах из промерзающих и не промерзающих почв. Автором высказано предположение, что эти различия может быть и выступили бы, если исследованию подвергались бы микоризы из горизонта В.

Вместо того, автором констатировано сильное влияние на морфологию микориз, оказанное красными глинами в южных штатах, в этих именно глинах короткие корешки (*rootlets*) характеризовались сильным гипертрофическим утолщением.

Микоризы в песках развивались в виде удлинённых и удивительно плохо сформированных коротких корешков, поверхность которых была обильно покрыта щетинками (*setae*).

Микоризы развивающиеся во влажных почвах произрастают удлиненные и имеют очень нежное и прозрачное строение.

О влиянии климата можно сказать, что в самой северной части предела микоризы развиваются только в течение короткого лета, еще даже в половине мая не констатировано возникновения микоризы у бука, тогда как на юге молодые микоризы формируются непрерывно в течение всего года.

Между севером и югом существует разница в условиях заимствования воды. В штате Вермонт во время зимы наступает физиологическая засуха вследствие промерзания почвы, тогда как на юге зимы дождливы, благодаря чему они являются сезонами развития, а лета — сухие. Можно предполагать, что интересное сформирование коротких корешков, которое было обнаружено в западной Флориде, обусловлено их развитием в теплой песчаной почве и теплых почвенных растворах (*ground-water*).

ÜBER DIE KURZWURZELN UND ENDWURZELN DER BUCHE, DES AHORNS UND DES HARTRIEGELS, DIE SICH IN BÖDEN DER ÖSTLICHEN STAATEN NORDAMERIKAS BILDEN

Zusammenfassung

Einer Forschungsprobleme über den Mykotrophismus ist Morphologie der Mykorrhizen. Man kann es überlegen, ob sie von der Wirkung des infizierenden Pilzes, ob von der infizierten Pflanzen oder vielleicht vom Zusammenwirken dieser beiden in den gegebenen Umweltbedingungen abhängig ist.

Zwecks Erklärung dieser Angelegenheiten, soviel es überhaupt möglich ist, hat der Verfasser die Forschungen über eine gewisse Anzahl der Baummykorrhizen in östlichen Staaten Nordamerikas durchgeführt. Er hat zu den Forschungen die Holzgattungen: Buche, Ahorn und Hartriegel aus zwei Gründen gewählt und nämlich deswegen, weil diese Holzarten längs des atlantischen Küste Amerikas vorkommen und weil jede dieser Holzgattungen deutlich verschiedene Kurzwurzeln besitzt.

Beim Vorkommen längs der ganzen Ausdehnung der atlantischen Küste Amerikas, wachsen diese Bäume auf sehr verschiedenen Böden. Sie treten auf den gefrierenden Böden nördlich von der wellenartigen Linie, die durch die Staaten: New York, New Jersey und Pensilvanien läuft und auf nie gefrierenden Böden im Süden der Staaten vor. In beiden Gebieten wachsen sie auf armen und fruchtbaren Böden: auf Ton-, Lehm-, Kies-, Sand- und Marschböden, auf flachgründigen Felsenböden als auch auf tiefgründigen Böden mit dem gebildeten Bodenprofil. Besonders soll man die Aufmerksamkeit auf rote Lehmböden im Süden der Staaten lenken.

Außerdem soll es daran erinnert werden, dass dieses weite Verbreitungsgebiet sich vom kalten Klima Kanadas bis zum subtropischen Klima an

der südlichen Grenze Floridas ausdehnt. Auf dem Terrain des Staates Vermont gefrieren die Böden jeden Winter, während sie in Florida nie gefrieren. Im Norden sind die Böden feuchter, im Süden dagegen sind sie während des langen Sommers ausgetrocknet.

Das Klima der ganzen Küste hat jedoch eine gemeinsame Eigenschaft in der Verteilung der Winde, welche abwechselnd von der Bucht (Gulf) nach Norden und von Kanada nach Süden wehen, was ein wenig geographisch begründete Unterschiede ausgleicht.

Bei der Wahl der Bäume, deren Verbreitungsgebiet diesen ganzen Streifen der Küste umfasst, hat Autor die Möglichkeit gehabt Wurzelproben in verschiedenen Boden- und Klimabedingungen zu sammeln. Autor hat nicht die Holzarten bestimmt und hat sich auf Holzgattungen begrenzt, weil es die Möglichkeiten eines Spezialisten überschreitet. Er hat die Wahl der Gattung *Fagus* mit seiner korallenartigen Mykorrhiza, der Gattung *Acer* mit seiner kettenartigen Mykorrhiza und der Gattung *Cornus* mit seiner einfachen Mykorrhiza vollbracht.

Nach der Darstellung seiner Beobachtungen zieht Autor den Schluss, das die Form der Mykorrhiza von der Holzgattung abhängt und prinzipiell unverändert bleibt ohne Rücksicht darauf, wo der Baum wächst. Der Verfasser widmet die flüchtige Aufmerksamkeit einem symbiontischen Pilze, den er als zufälligen Partner erachtet, den der Baum in der Entwicklung mit den osmotischen Funktionen begrenzt. Autor legt den Kurzwurzeln dieselbe Wichtigkeit im Leben der Pflanze, wie anderen Organen bei und stellt fest, dass die vorhandenen botanische Pflanzenbeschreibungen ungenügend sind, weil sie die Mykorrhizen fast gar nicht berücksichtigen.

Was den Einfluss des Bodens auf die Morphologie der Mykorrhizen anbelangt, begrenzt der Verfasser seine Forschungen nur auf das Horizont A und er forscht nicht Mykorrhizen in verschiedenen Horizonten des Bodenprofils.

Er hat auch nicht die deutlicheren Unterschiede in den Mykorrhizen der gefrierenden und nicht gefrierenden Böden beobachtet. Er vermutet, das vielleicht diese Unterschiede beim Forschen der Mykorrhizen aus dem Horizont B hervortreten würden.

Er hat dagegen einen starken Einfluss den auf die Morphologie der Mykorrhizen rote Lehme in südlichen Staaten ausüben festgestellt, wo in den Lehmen sich die Kurzwurzeln durch eine starke hypertrophische Verdickung charakterisierten.

Die Mykorrhizen in Sanden entwickelten sich als verlängerte und sonderbar geformte Kurzwurzeln, deren Oberfläche reichlich mit Borsten (setae) bedeckt war.

Mykorrhizen die sich in nassen Böden entwickelten wuchsen ausgedehnt und hatten einen sehr zarten und durchsichtigen Bau.

Über den Einfluss des Klimas darf es gesagt werden, dass die Mykorrhizen im am meisten nördlichen Verbreitungsteil sich nur im Laufe des kurzen Sommers entwickeln, sogar noch in der Hälfte Mai ist die Entstehung der Mykorrhizen bei Buche nicht festgestellt worden, während im Süden die jungen Mykorrhizen das ganze Jahr hindurch ununterbrochen geformt werden.

Zwischen dem Norden und Süden besteht ein Unterschied in den Bedingungen der Wasseraufnahme. Im Staate Vermont herrscht im Winter eine physiologische Dürre infolge des Gefrierens des Bodens, im Süden dagegen sind die Winter regnerisch, weswegen sie Entwicklungsperioden sind und die Sommer sind trocken. Man dürfte es vermuten, dass die merkwürdige in Westflorida gefundene Gestaltung der Wurzeln der letzten Ordnung durch die Entwicklung im warmen Sandboden und in warmen Bodenlösungen (ground-water) bedingt ist.

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